Figure 7.1 The Nature of Waves

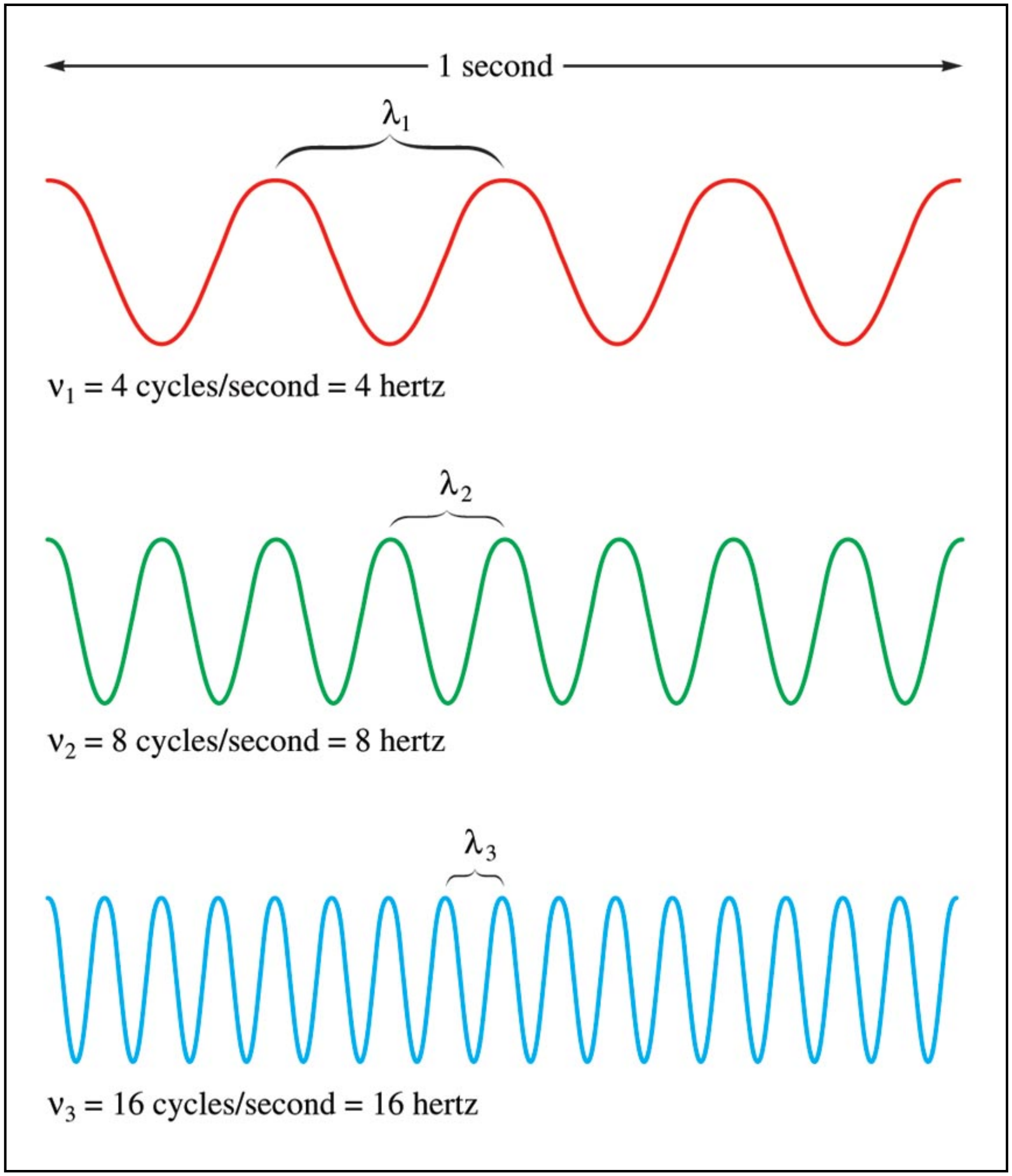


Figure 7.2 The Electromagnetic Spectrum

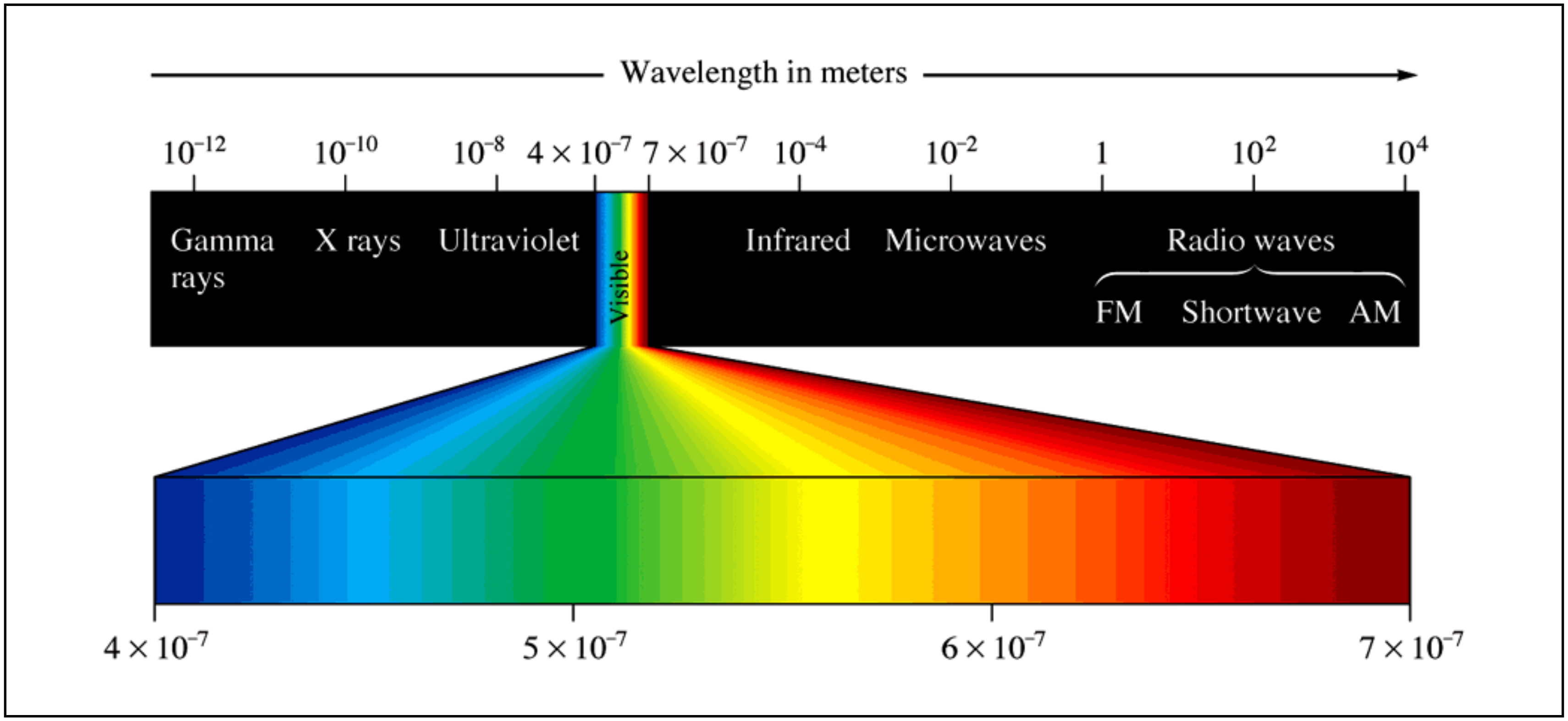
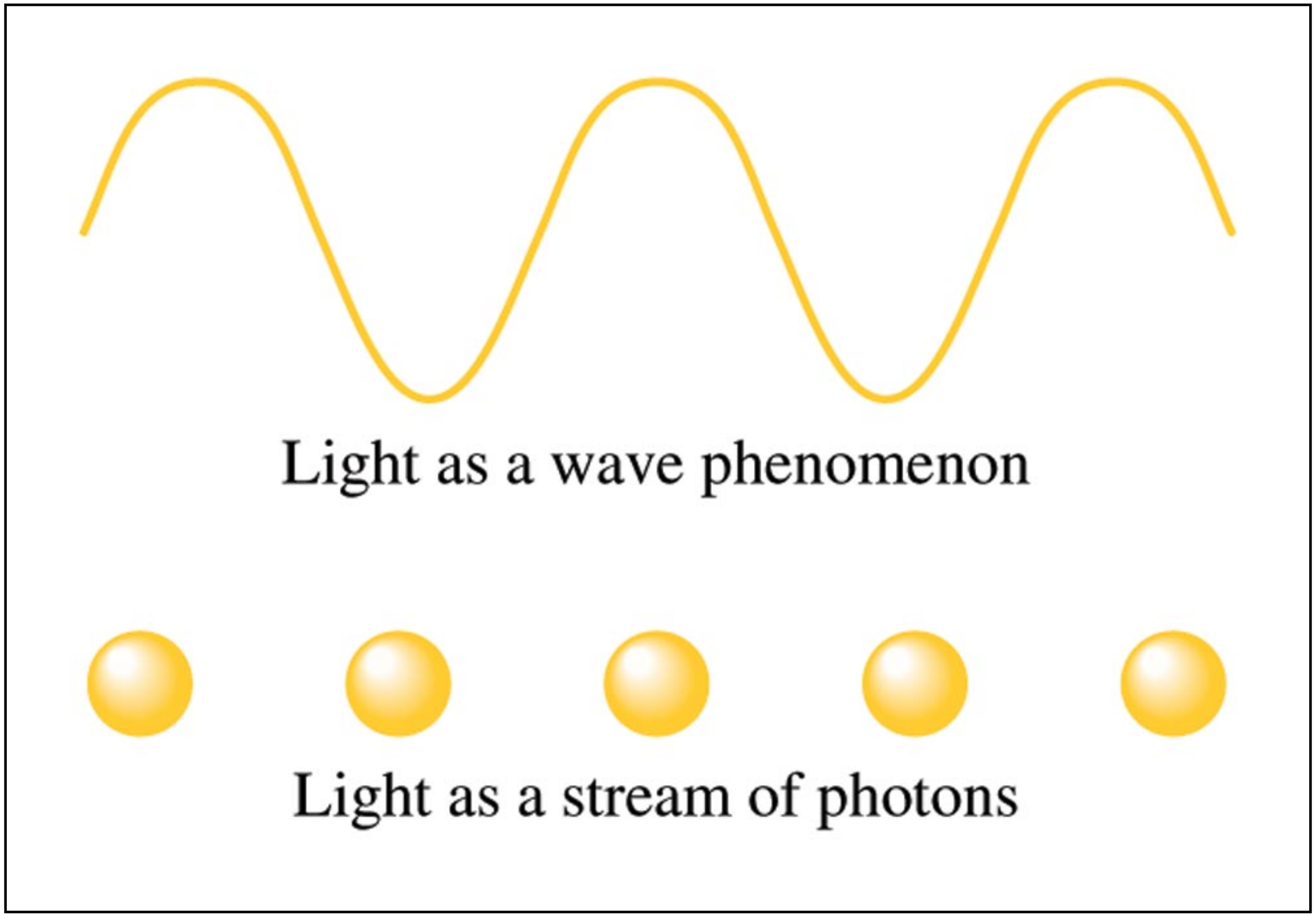
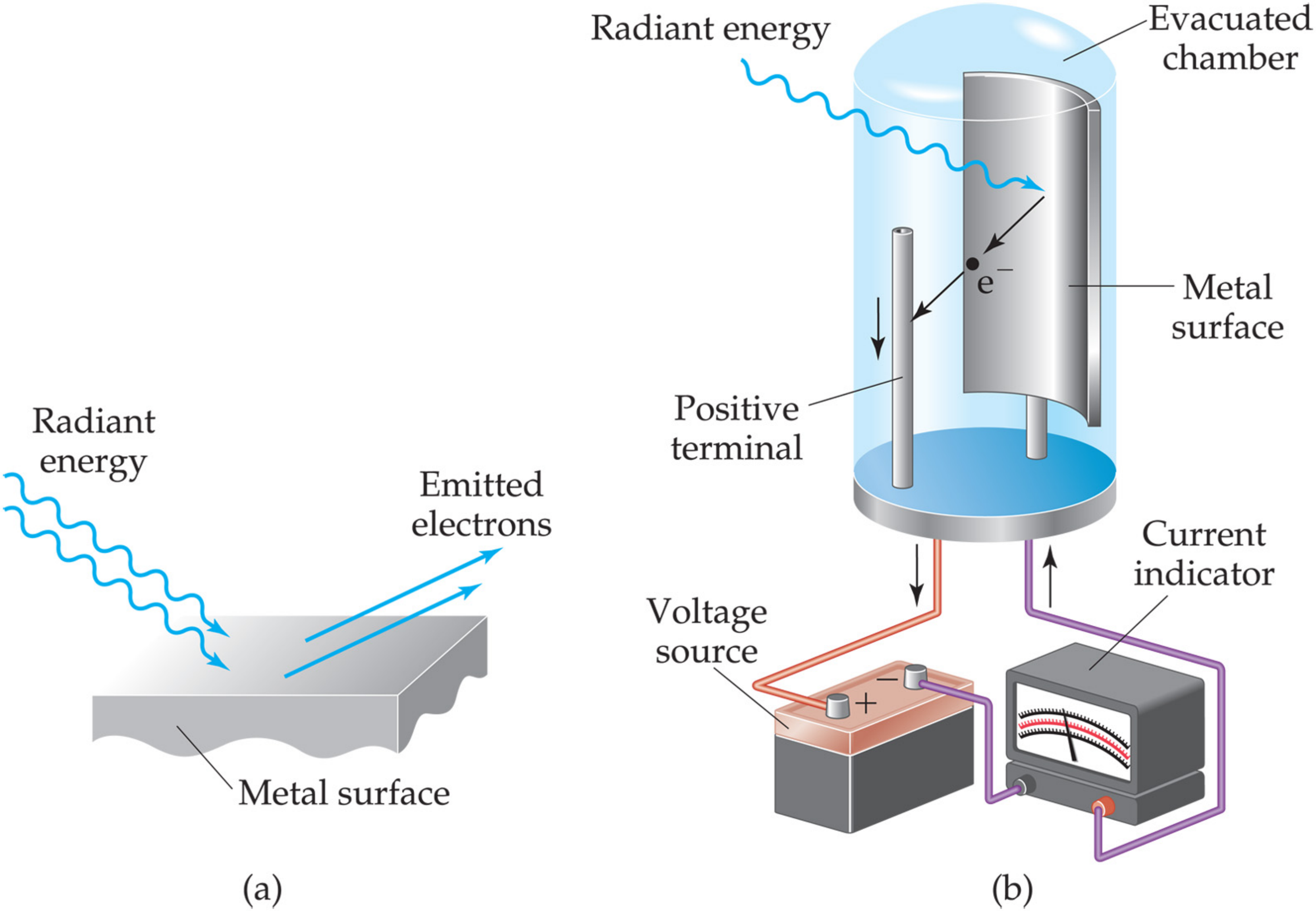


Figure 7.4 Electromagnetic Radiation Exhibits Wave Properties and Particulate Properties (dual nature of light)




Radiant energy
Emitted electrons
Metal surface
(a)
Radiant energy
Evacuated chamber
e⁻
Metal surface
Positive terminal
Current indicator
Voltage source
+
−
(b)

Einstein's Major Points on Photoelectric Effect

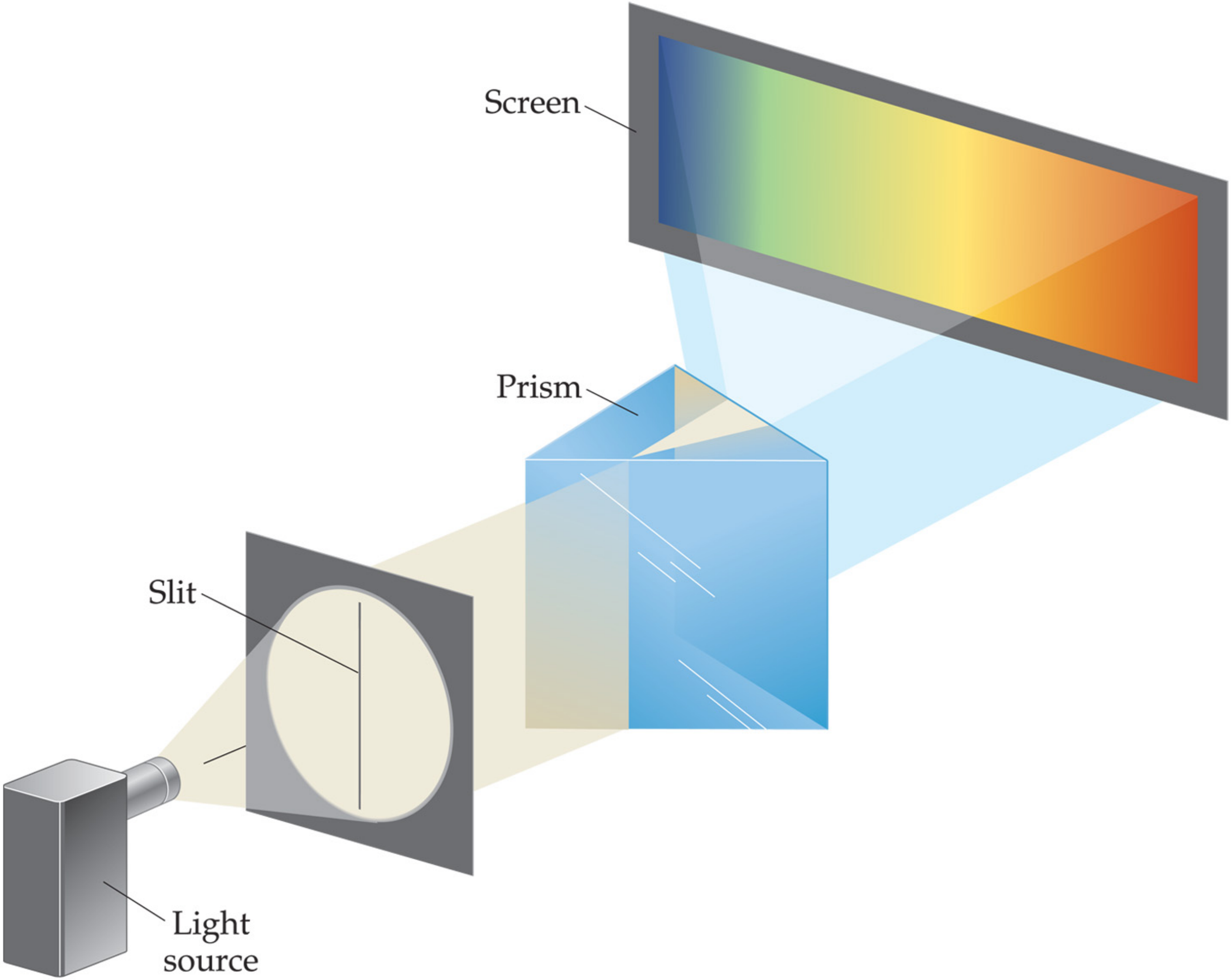
1. No e^- are emitted by metal hit w/ light below specific threshold ν (ν_o)

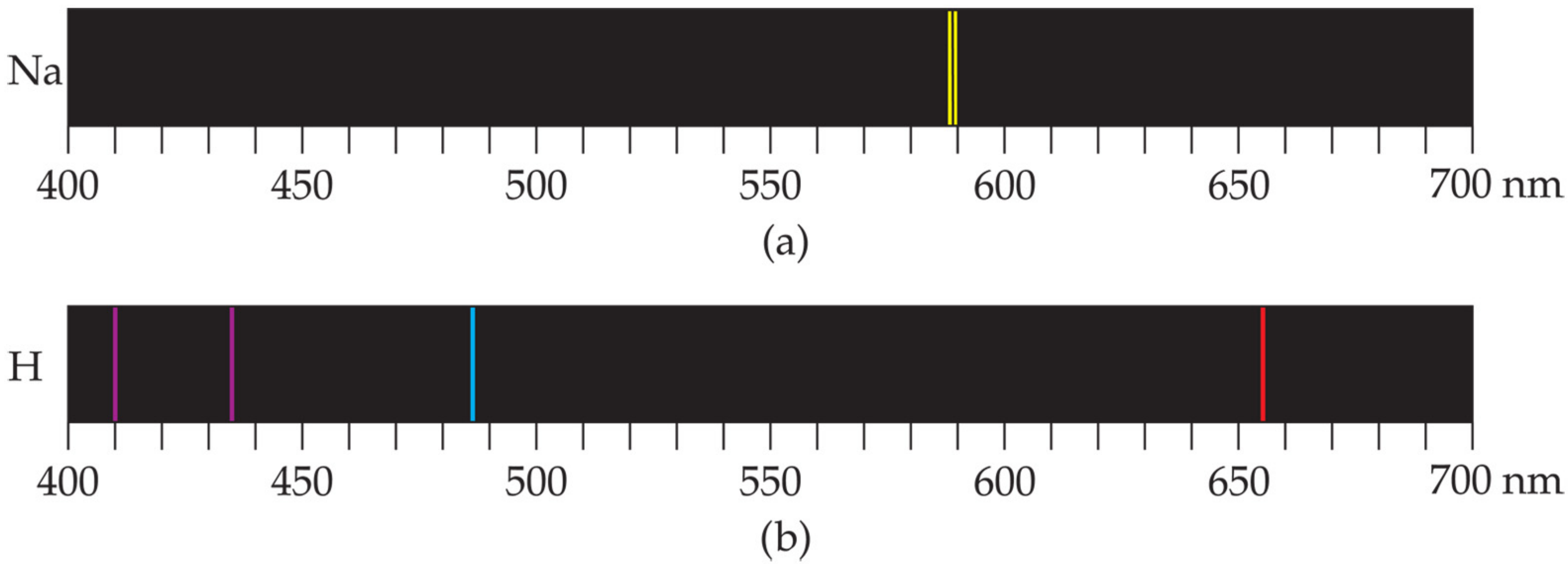
2. Light w/ ν below ν_o: No e^- emitted (regardless of intensity)

3. Light w/ ν above ν_o: # of e^- increase with intensity of light

4. Light w/ ν above ν_o: the KE of the emitted e^- increases linearly w/ ν of light

Insert Layman's terms here


Screen
Prism
Slit
Light source


Na
400
450
500
550
600
650
700 nm
(a)
H
400
450
500
550
600
650
700 nm
(b)

Glowing pickle from exciting sodium ions

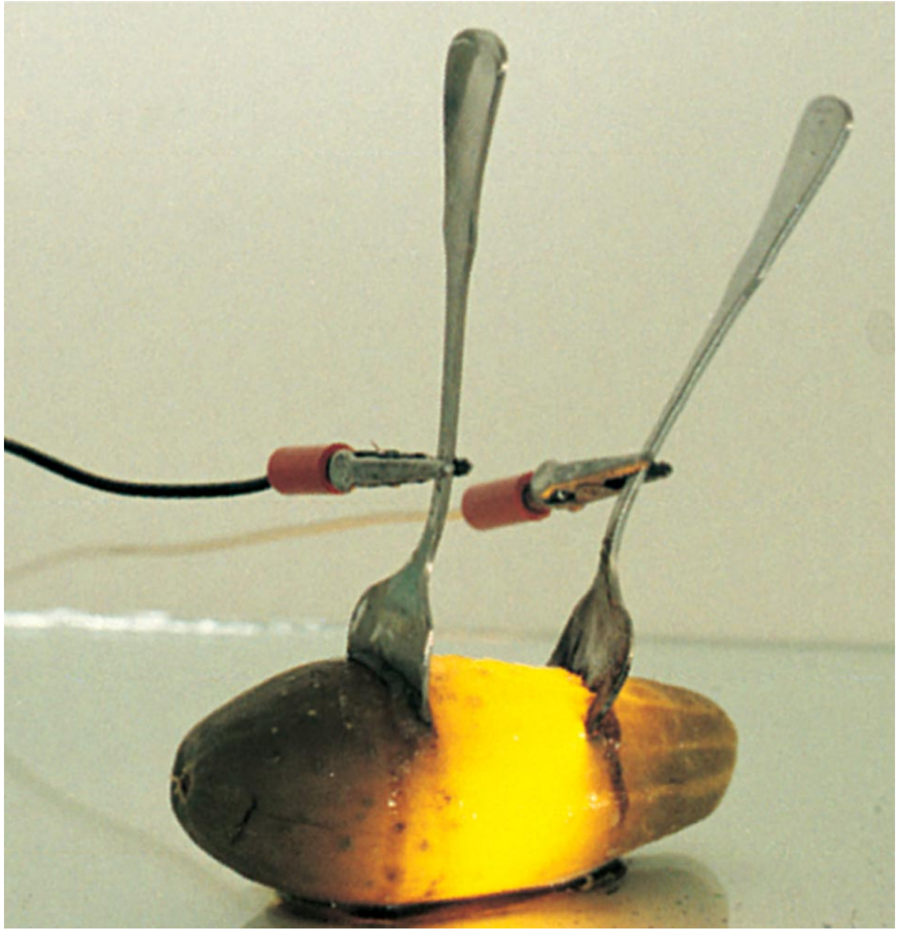


Figure 7.7 A Change Between Two Discrete Energy Levels Emits a Photon of Light

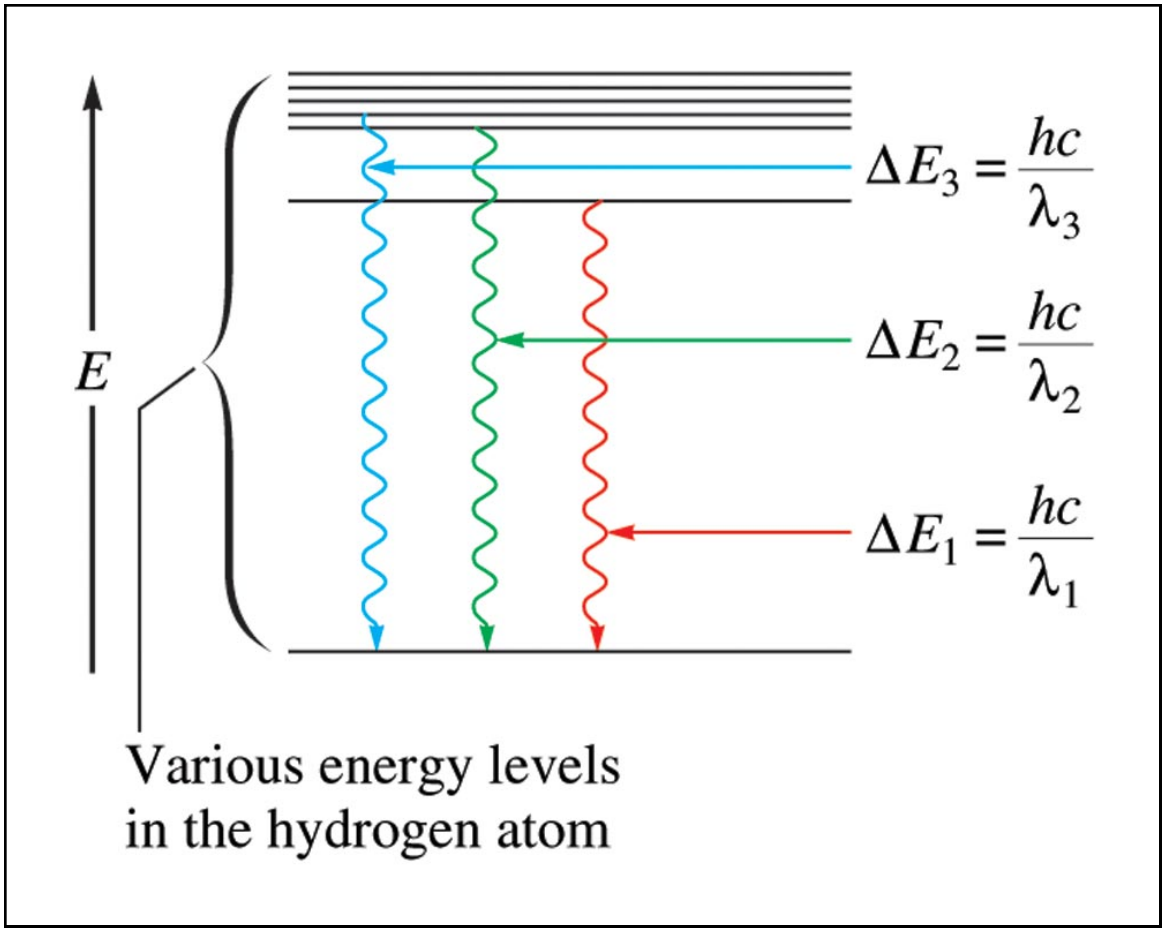


Figure 7.8 Electronic Transitions in the Bohr Model for the Hydrogen Atom

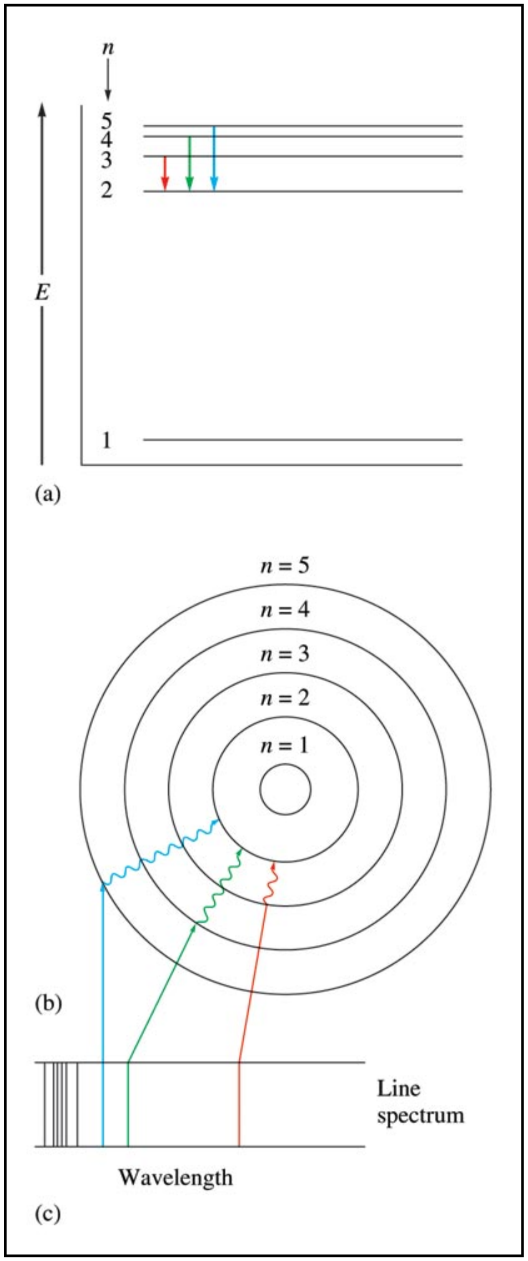
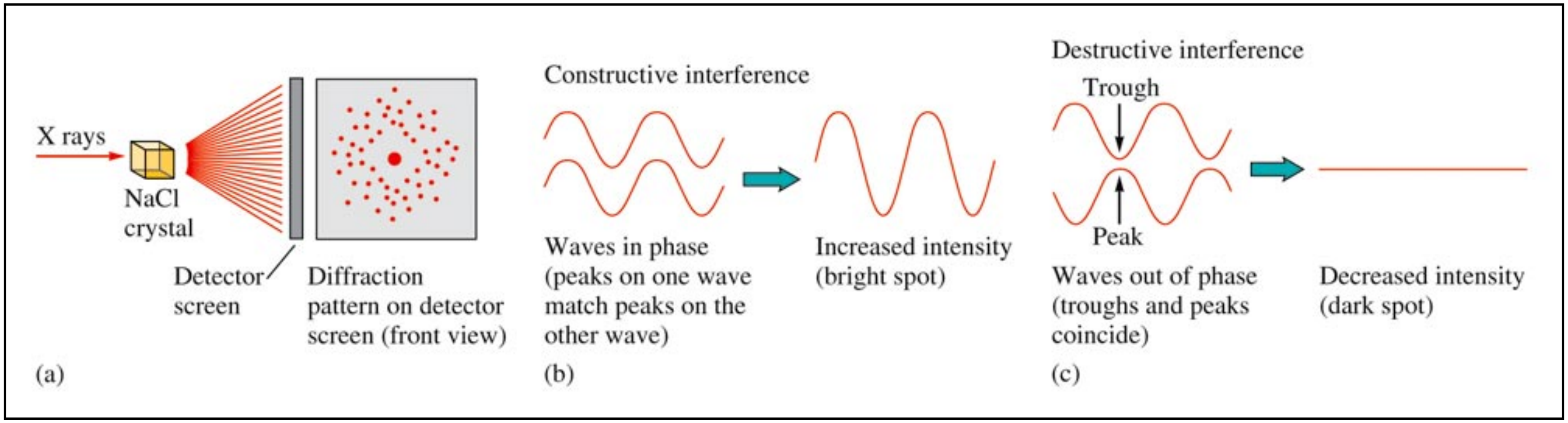


Figure 7.5 a-c (a) Diffraction Pattern (b) Constructive Interference of Waves (c.) Destructive Interference of Waves



Images of Diffracted Electrons

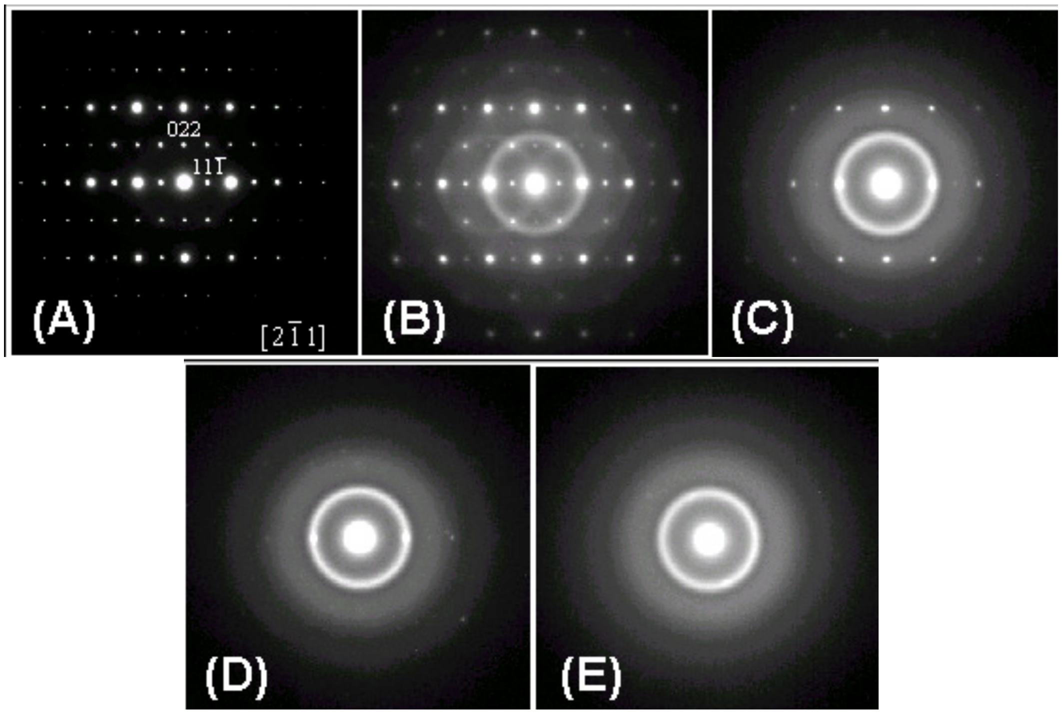


Figure 7.9 The Standing Waves Caused by the Vibration of a Guitar String

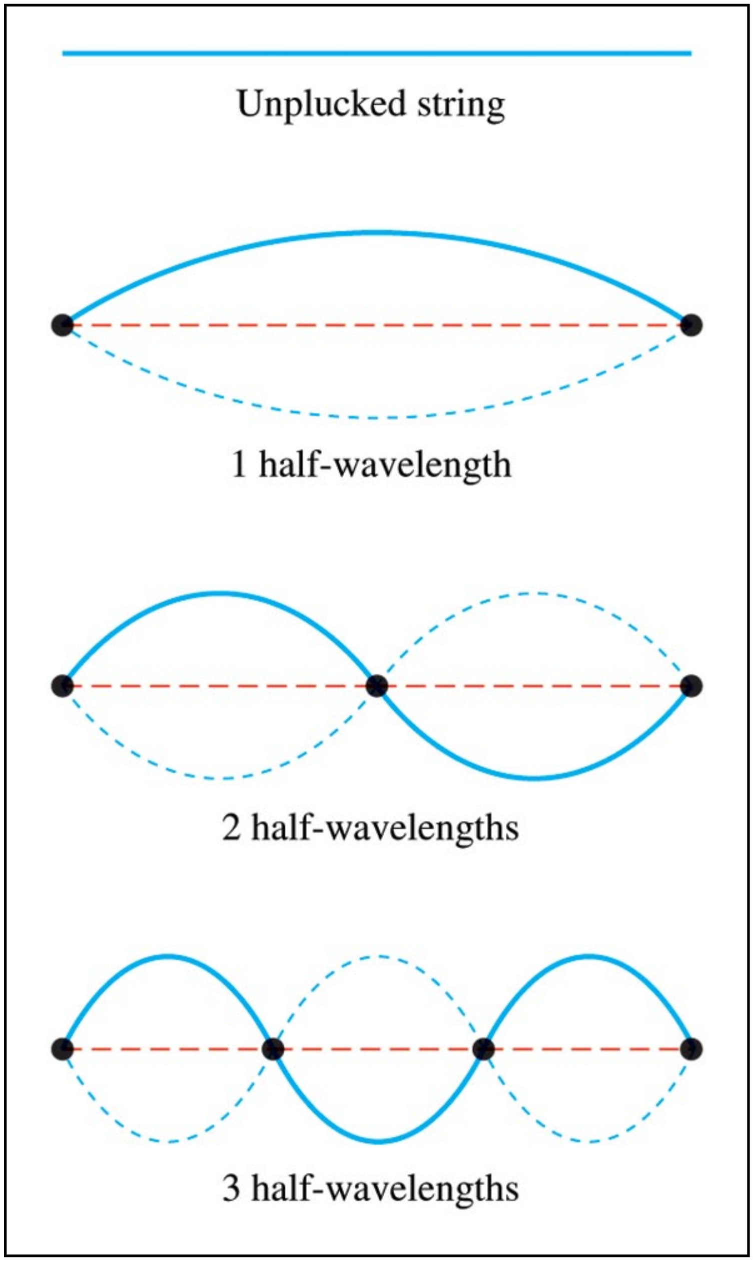


Figure 7.10 The Hydrogen Electron Visualized as a Standing Wave Around the Nucleus

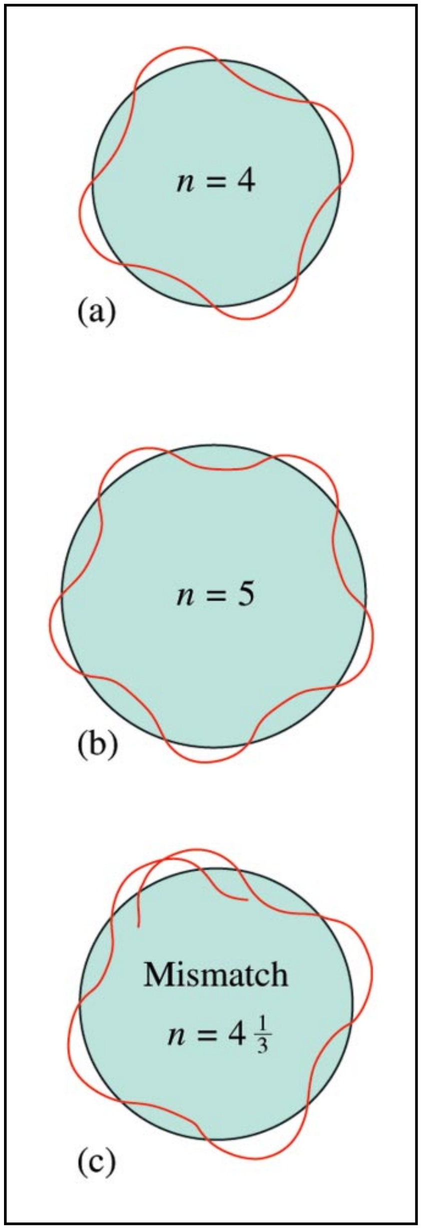


Figure 7.11 a&b (a) The Probability Distribution for the Hydrogen 1s Orbital in Three-Dimensional Space (b) The Probability of Find the Electron at Points Along a Line Drawn From the Nucleus Outward in Any Direction for the Hydrogen 1s Orbital

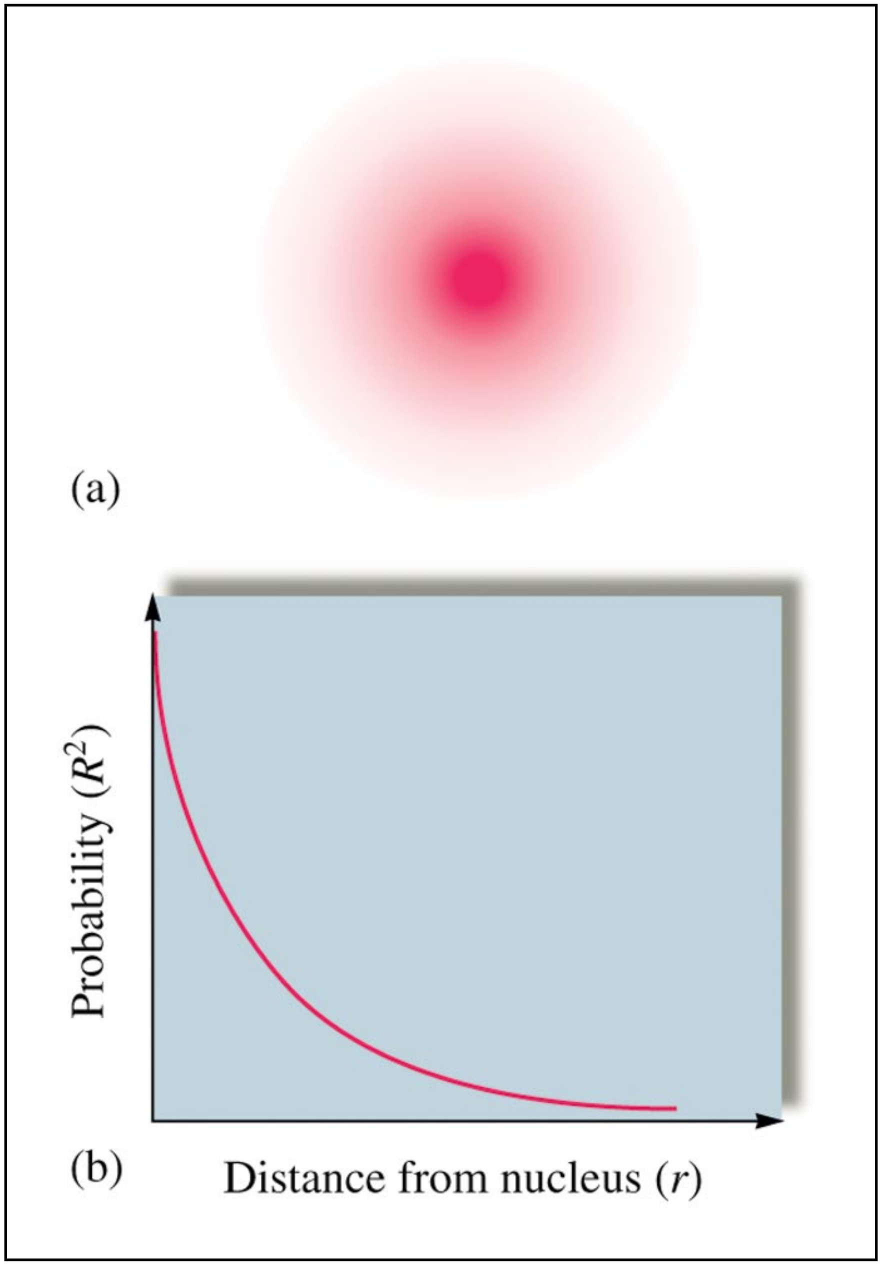


Figure 7.12 a&b Cross Section of the Hydrogen 1s Orbital Probability Distribution Divided into Successive Thin Spherical Shells (b) The Radial Probability Distribution

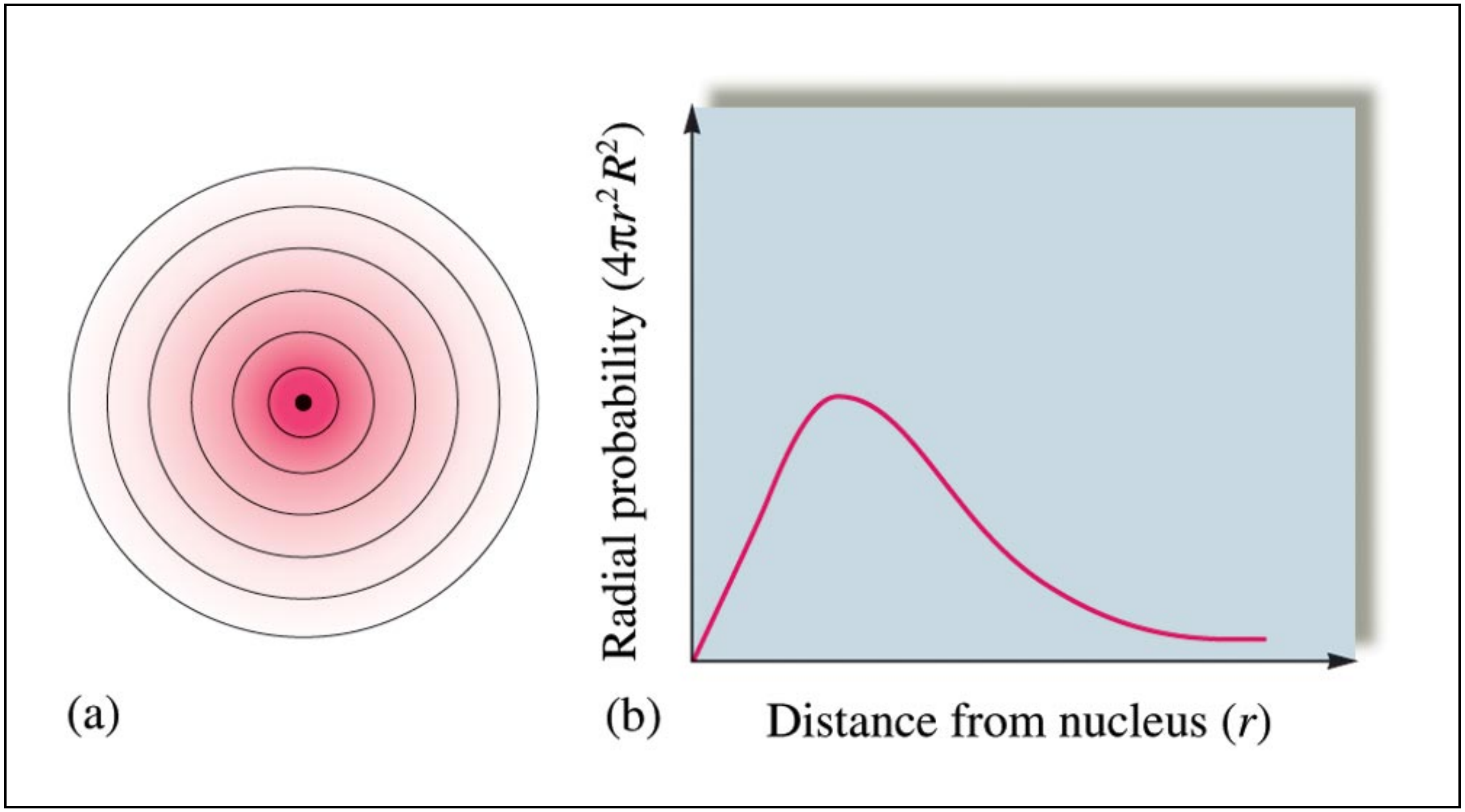


TABLE 7.1 The Angular Momentum Quantum Numbers and Corresponding Letters Used to Designate Atomic Orbitals

Value of ℓ	0	1	2	3	4
Letter Used	*s*	*p*	*d*	*f*	*g*

TABLE 7.2 Quantum Numbers for the First Four Levels of Orbitals in the Hydrogen Atom

n	ℓ	Orbital Designation	m_ℓ	Number of Orbitals
1	0	1*s*	0	1
2	0	2*s*	0	1
	1	2*p*	−1, 0, +1	3
3	0	3*s*	0	1
	1	3*p*	−1, 0, 1	3
	2	3*d*	−2, −1, 0, 1, 2	5
4	0	4*s*	0	1
	1	4*p*	−1, 0, 1	3
	2	4*d*	−2, −1, 0, 1, 2	5
	3	4*f*	−3, −2, −1, 0, 1, 2, 3	7

Figure 7.13 Two Representations of the Hydrogen 1s, 2s, and 3s Orbitals (a) The Electron Probability Distribution (b) The Surface Contains 90% of the Total Electron Probability (the Size of the Oribital, by Definition)

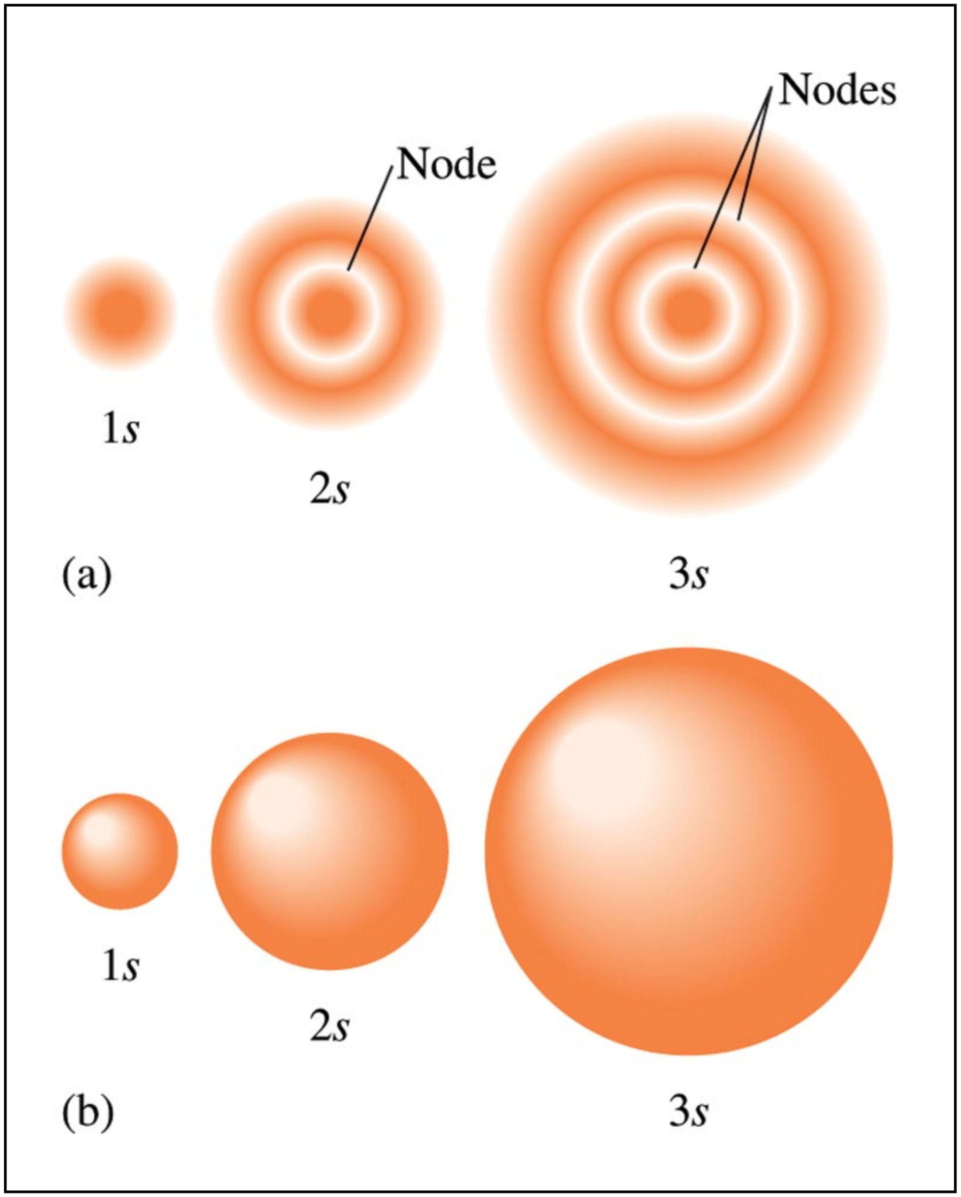
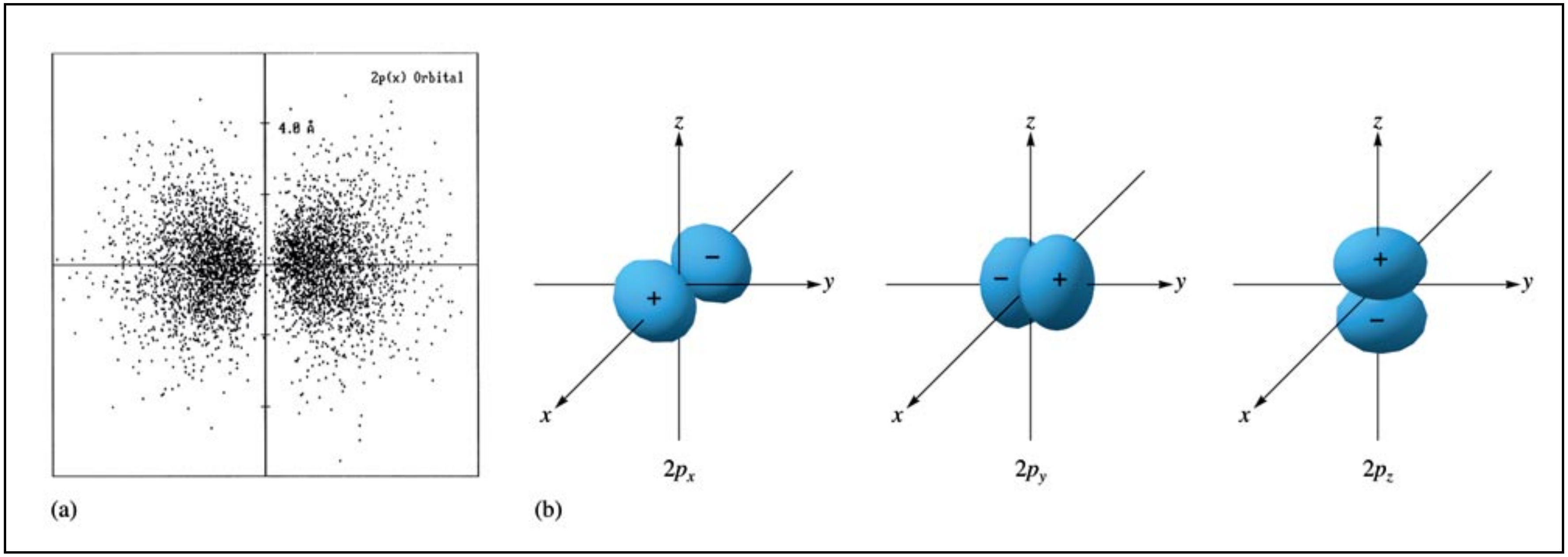


Figure 7.14 a&b Representation of the 2p Orbitals (a) The Electron Probability Distribution for a 2p Oribtal (b) The Boundary Surface Representations of all Three 2p Orbitals



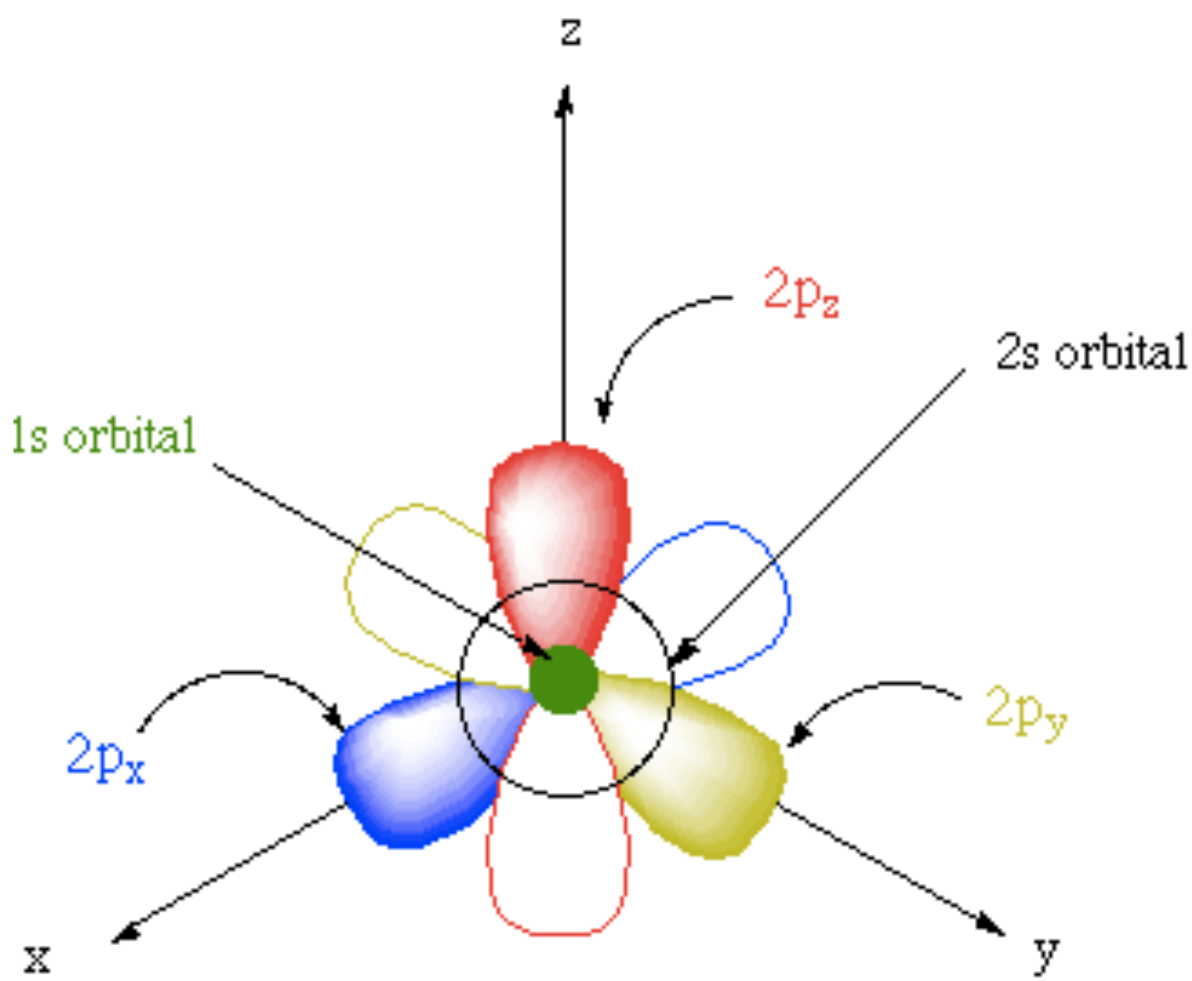

z
2p$_z$
2s orbital
1s orbital
2p$_x$
2p$_y$
x
y

Figure 7.15 A Cross Section of the Electron Probability Distribution for a 3p Orbital

Figure 7.16 a&b Representation of the 3d Orbitals (a) Electron Density Plots of Selected 3d Orbitals (b) The Boundary Surfaces of All of the 3d Orbitals

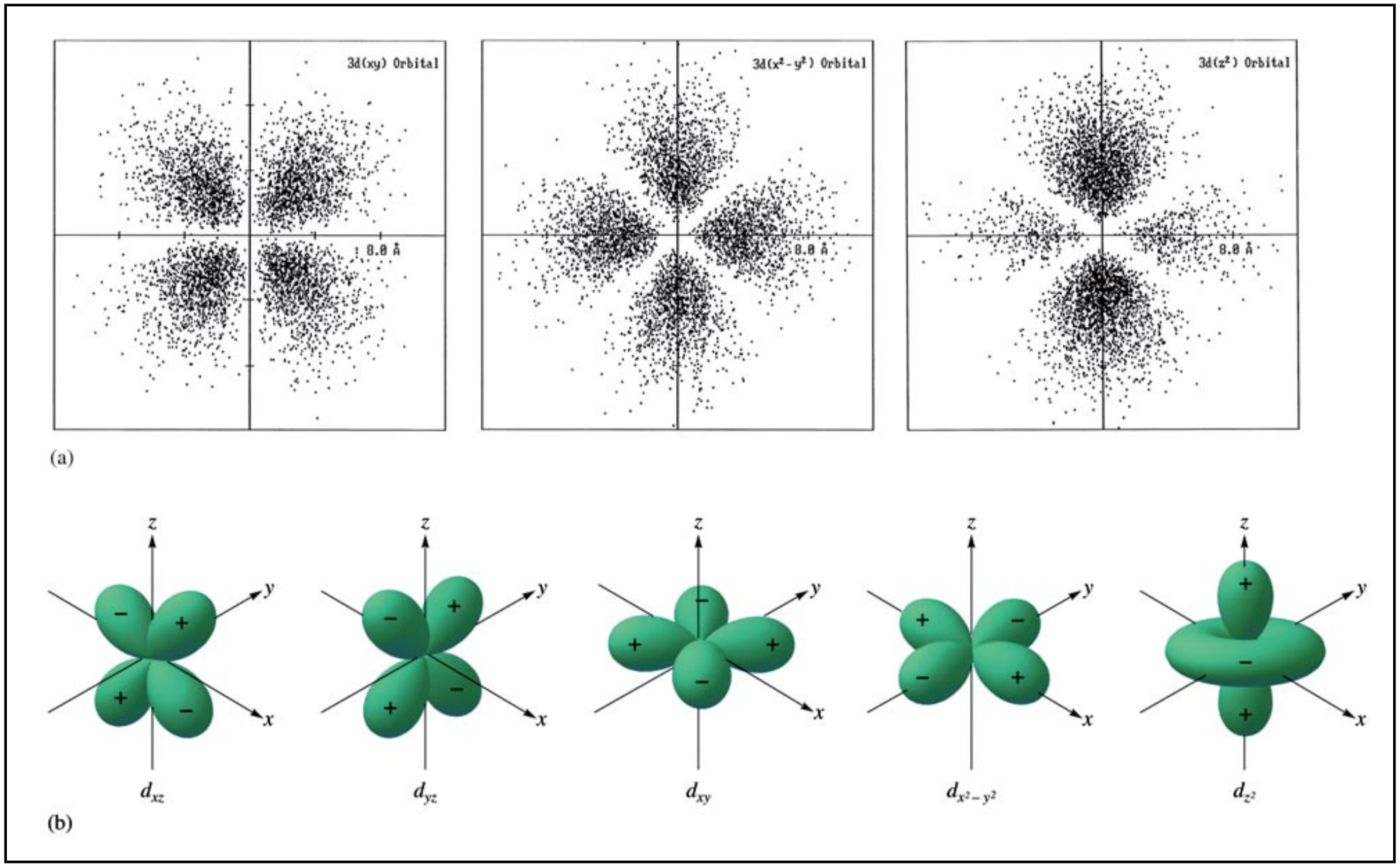


Figure 7.17 Representation of the 4f Orbitals in Terms of Their Boundary Surfaces

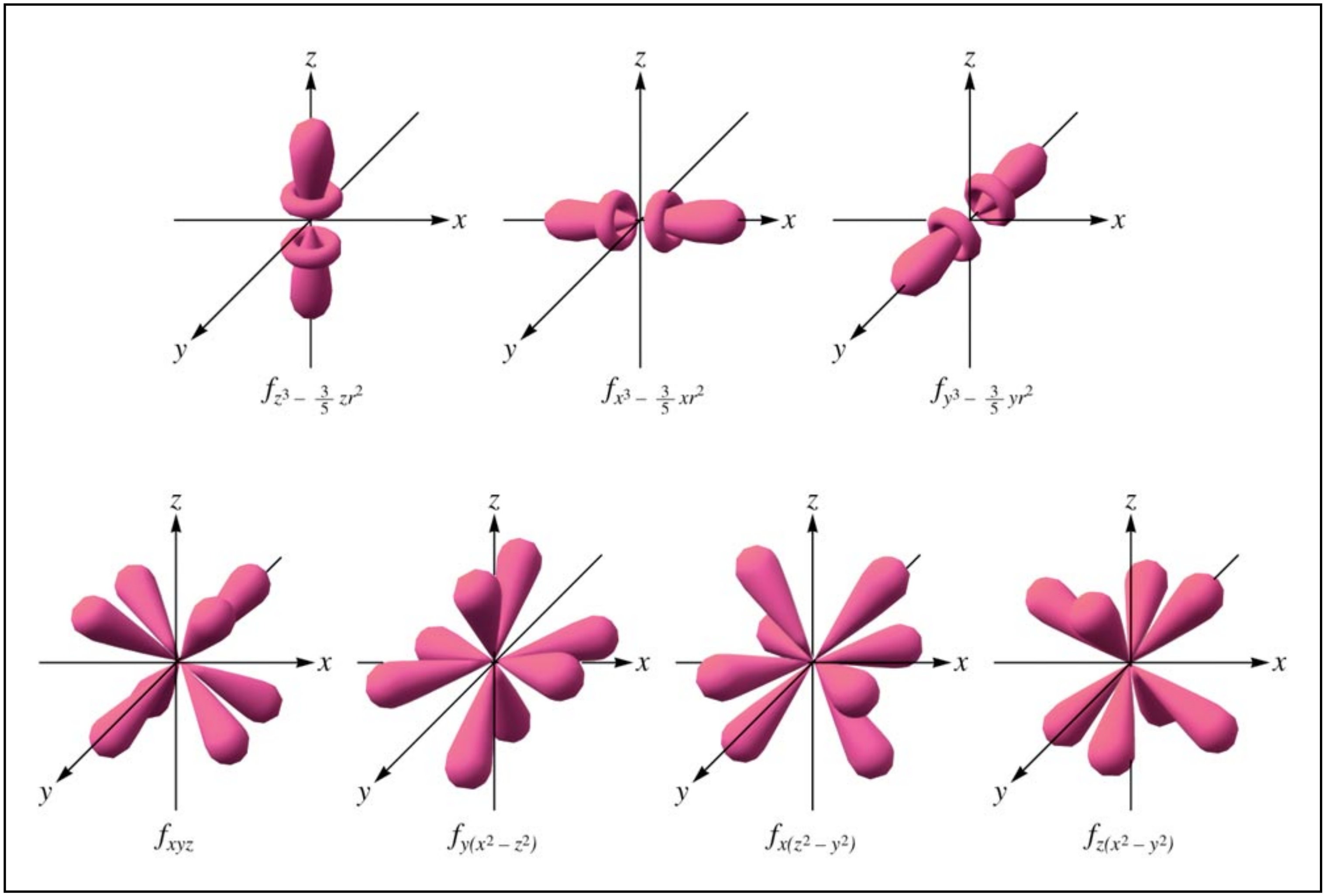


Figure 7.18 Orbital Energy Levels for the Hydrogen Atom

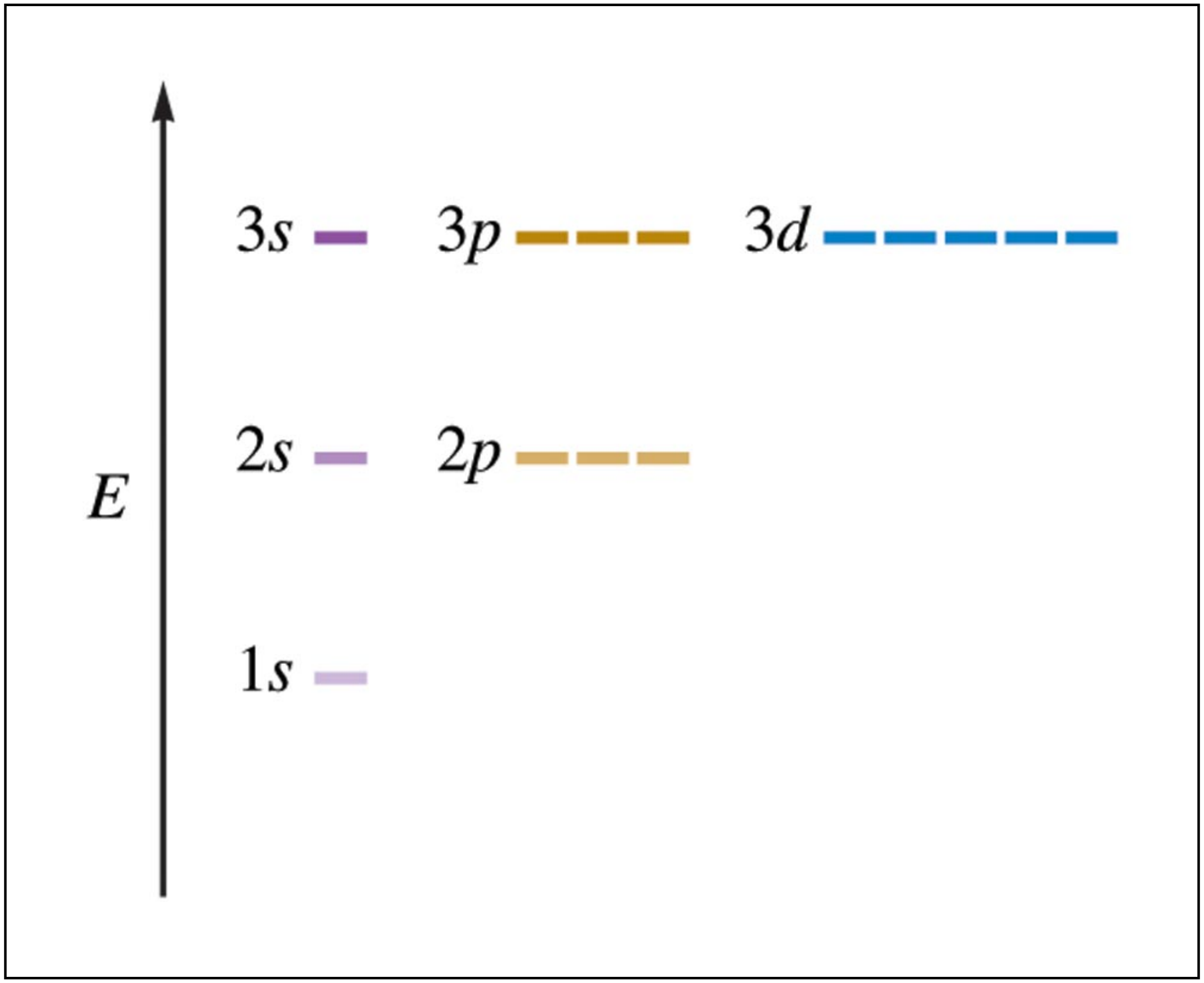


Figure 7.19 A Picture of the Spinning Electron

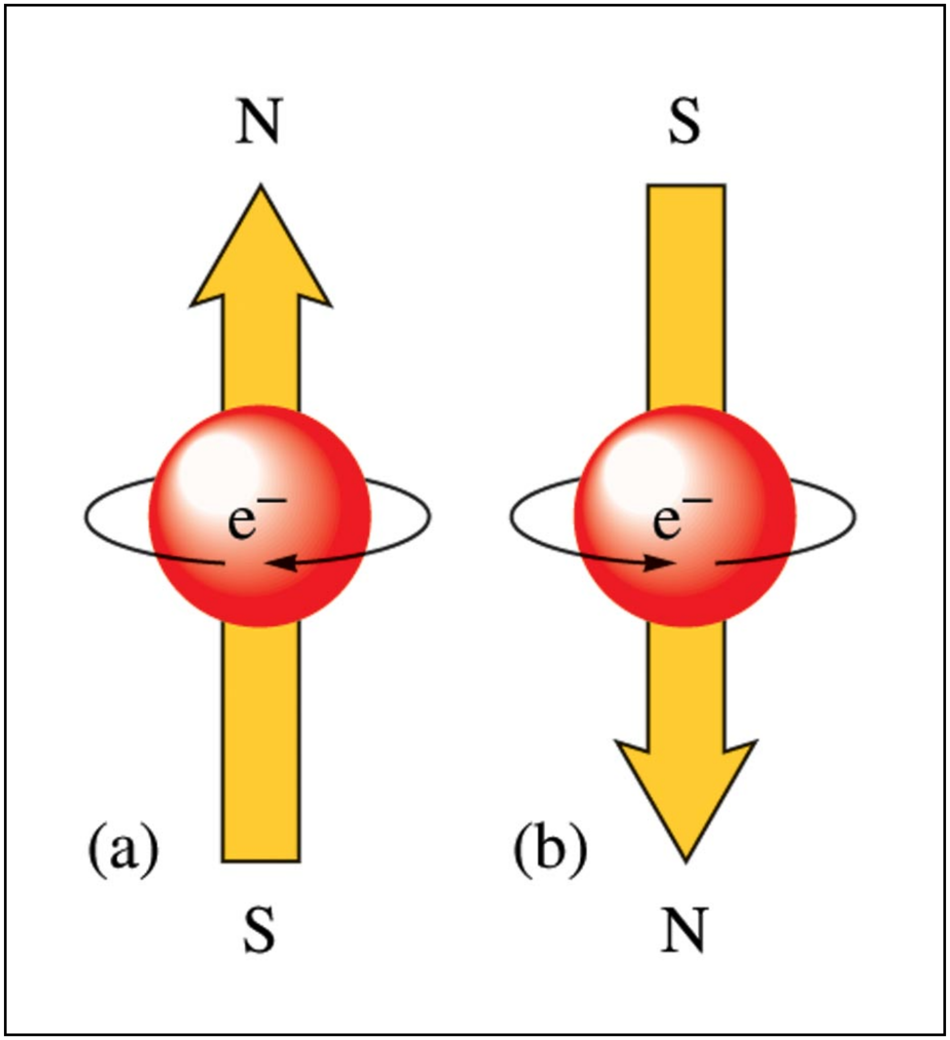


Figure 7.20 A Comparison of the Radial Probability Distributions of the 2s and 2p Orbitals

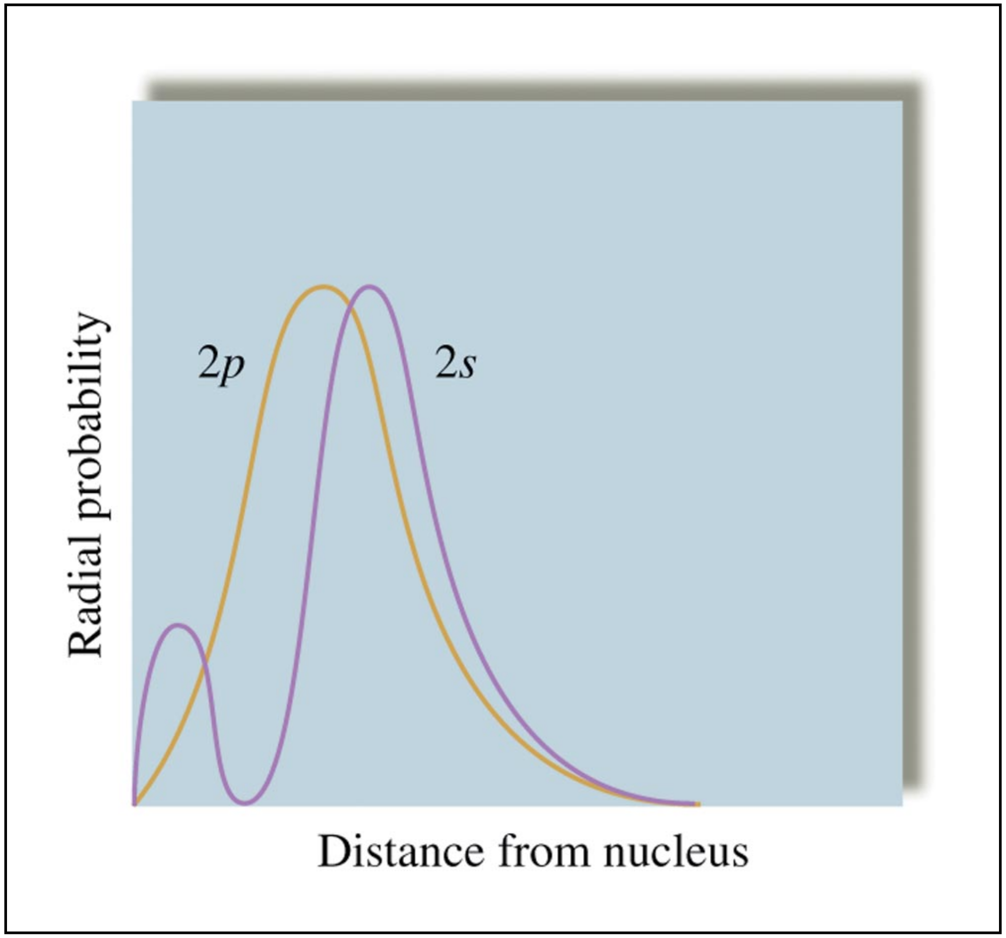


Figure 7.21 (a) The Radial Probability Distribution for an Electron in a 3s Orbital (b) The Radial Probability Distribution for the 3s, 3p, and 3d Orbitals

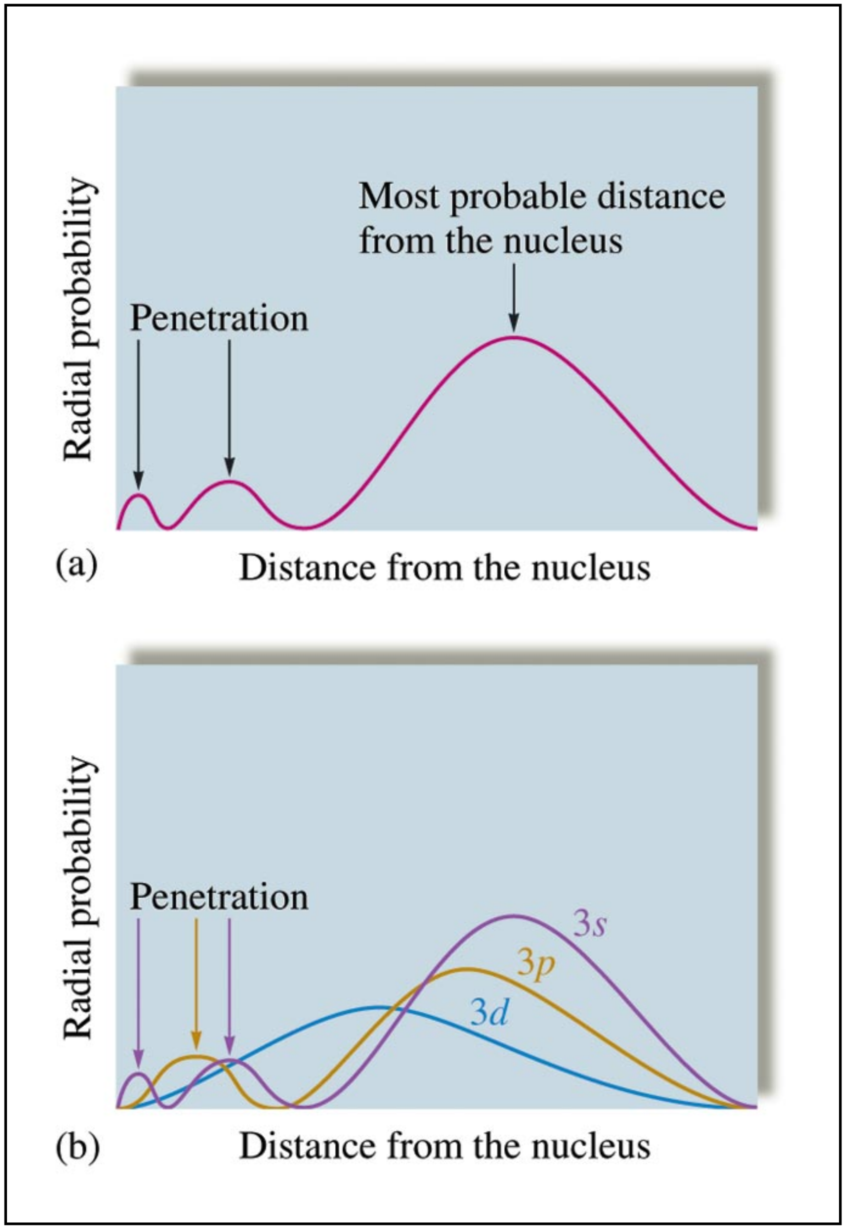
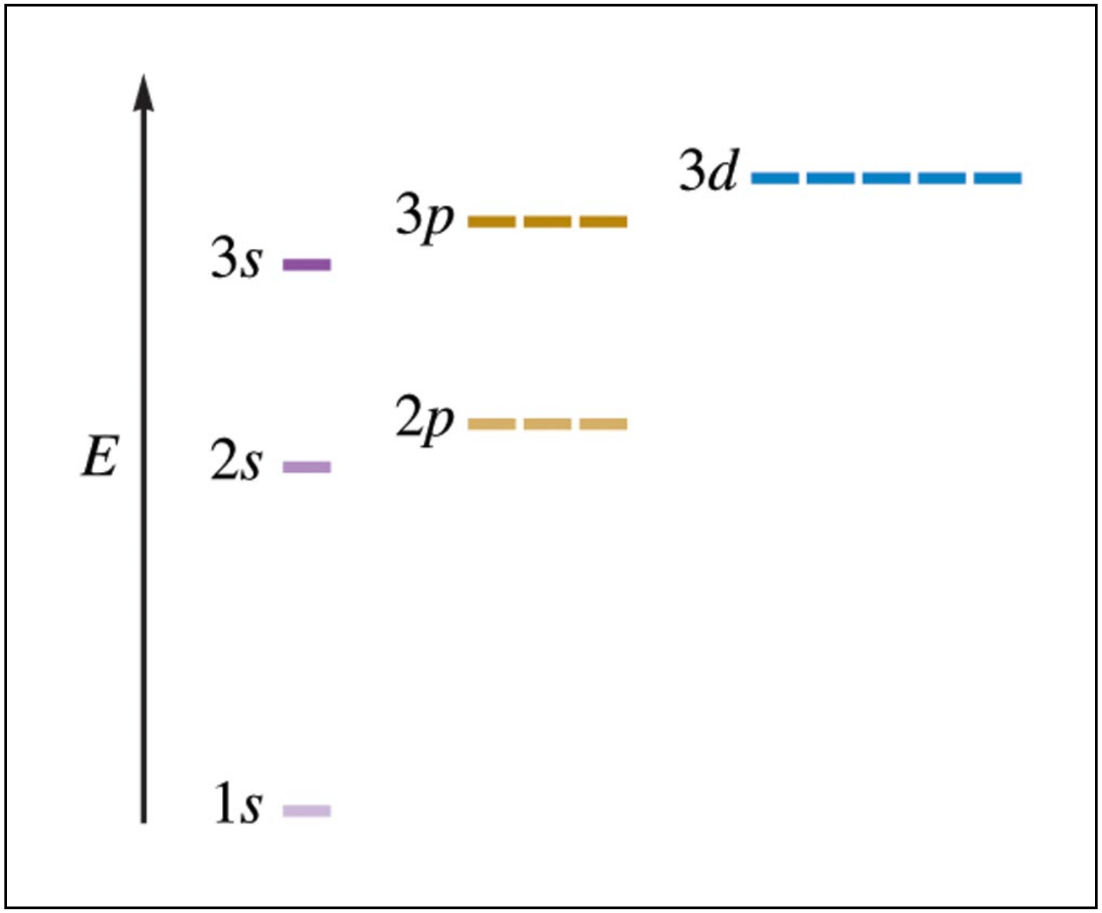


Figure 7.22 The Orders of the Energies of the Orbitals in the First Three Levels of Polyelectronic Atoms



Mendeleev's Early Periodic Table

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

			Ti=50	Zr=90	?=180.
			V=51	Nb=94	Ta=182.
			Cr=52	Mo=96	W=186.
			Mn=55	Rh=104,4	Pt=197,4.
			Fe=56	Rn=104,4	Ir=198.
			Ni=Co=59	Pl=106,6	Os=199.
H=1			Cu=63,4	Ag=108	Hg=200.
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204.
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

Д. Менделѣевъ

TABLE 7.3 Comparison of the Properties of Germanium as Predicted by Mendeleev and as Actually Observed

Properties of Germanium	Predicted in 1871	Observed in 1886
Atomic weight	72	72.3
Density	5.5 g/cm^3	5.47 g/cm^3
Specific heat	0.31 J/(°C · g)	0.32 J/(°C · g)
Melting point	Very high	960°C
Oxide formula	RO_2	GeO_2
Oxide density	4.7 g/cm^3	4.70 g/cm^3
Chloride formula	RCl_4	$GeCl_4$
bp of chloride	100°C	86°C

TABLE 7.4 Predicted Properties of Elements 113 and 114

Property	Element 113	Element 114
Chemically like	Thallium	Lead
Atomic mass	297	298
Density	16 g/mL	14 g/mL
Melting point	430°C	70°C
Boiling point	1100°C	150°C

Figure 7.25 The Electron Configurations in the Type of Orbital Occupied Last for the First 18 Elements

H $1s^1$								He $1s^2$
Li $2s^1$	Be $2s^2$		B $2p^1$	C $2p^2$	N $2p^3$	O $2p^4$	F $2p^5$	Ne $2p^6$
Na $3s^1$	Mg $3s^2$		Al $3p^1$	Si $3p^2$	P $3p^3$	S $3p^4$	Cl $3p^5$	Ar $3p^6$

Figure 7.26 Electron Configurations for Potassium Through Krypton

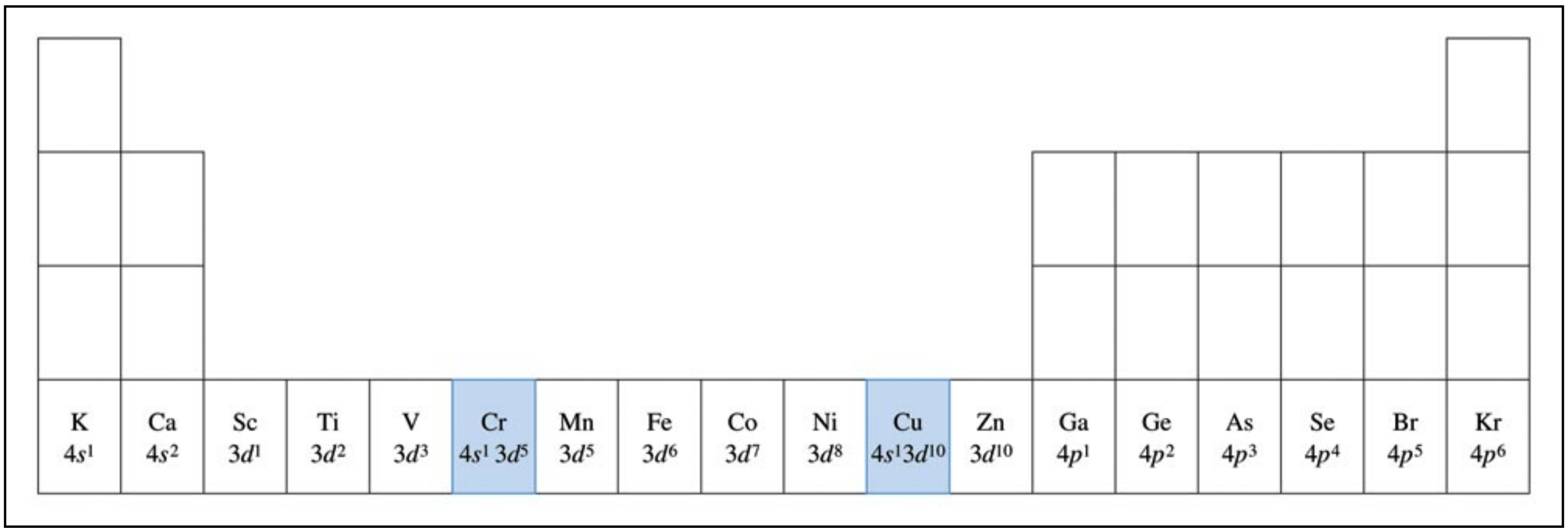


Figure 7.27 The Orbitals Being Filled for Elements in Various Parts of the Periodic Table

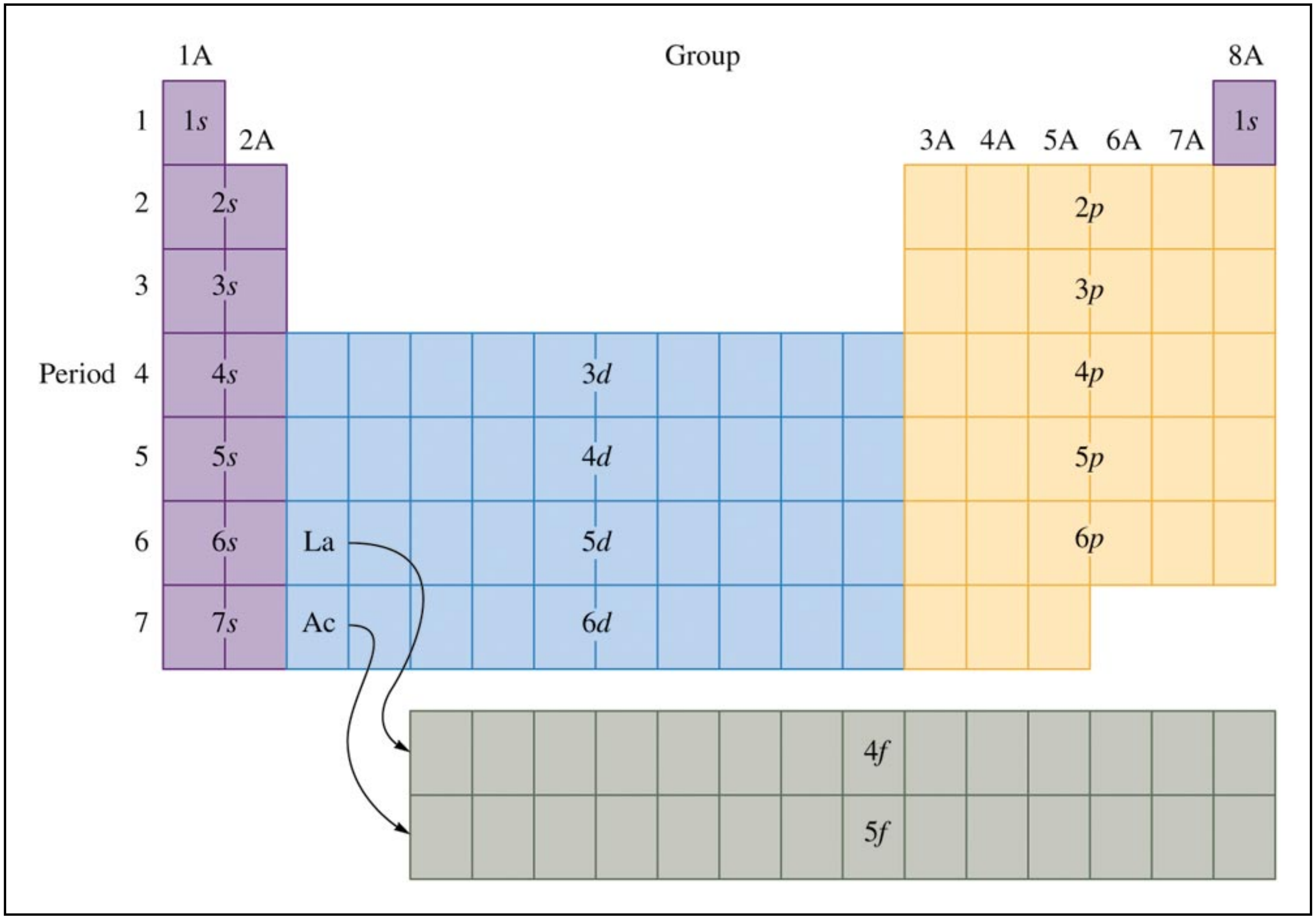


Figure 7.28 The Periodic Table with Atomic Symbols, Atomic Numbers, and Partial Electron Configurations

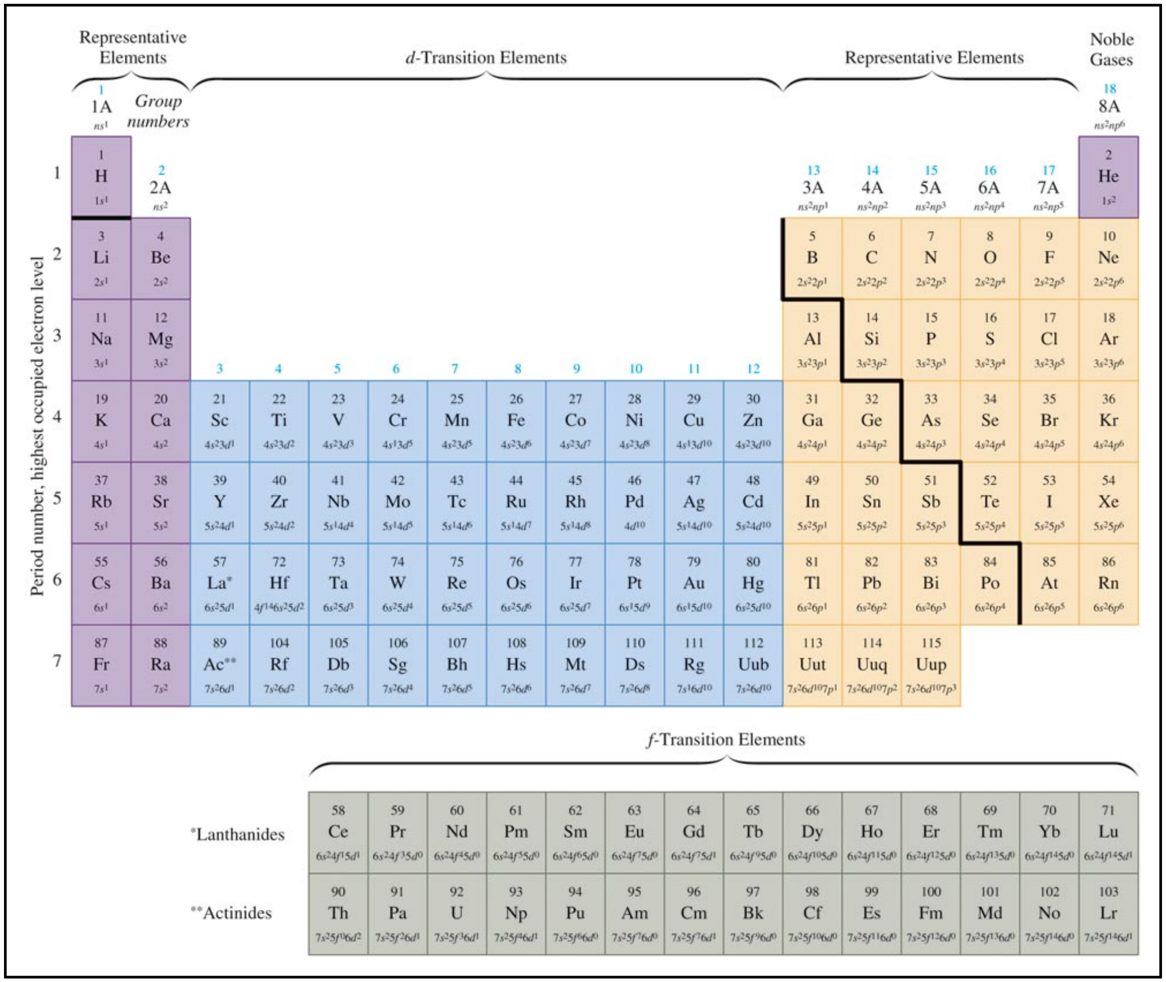


TABLE 7.5 Successive Ionization Energies in Kilojoules per Mole for the Elements in Period 3

Element	I_1	I_2	I_3	I_4	I_5	I_6	I_7
Na	495	4560					
Mg	735	1445	7730	Core electrons*			
Al	580	1815	2740	11,600			
Si	780	1575	3220	4350	16,100		
P	1060	1890	2905	4950	6270	21,200	
S	1005	2260	3375	4565	6950	8490	27,000
Cl	1255	2295	3850	5160	6560	9360	11,000
Ar	1527	2665	3945	5770	7230	8780	12,000

*Note the large jump in ionization energy in going from removal of valence electrons to removal of core electrons.

General decrease (down the group, vertical arrow)

General increase (across, horizontal arrow)

TABLE 7.6 First Ionization Energies for the Alkali Metals and Noble Gases

Atom	I_1(kJ/mol)
Group 1A	
Li	520
Na	495
K	419
Rb	409
Cs	382
Group 8A	
He	2377
Ne	2088
Ar	1527
Kr	1356
Xe	1176
Rn	1042

Figure 7.30 The Values of First Ionization Energy for the Elements in the First Six Periods

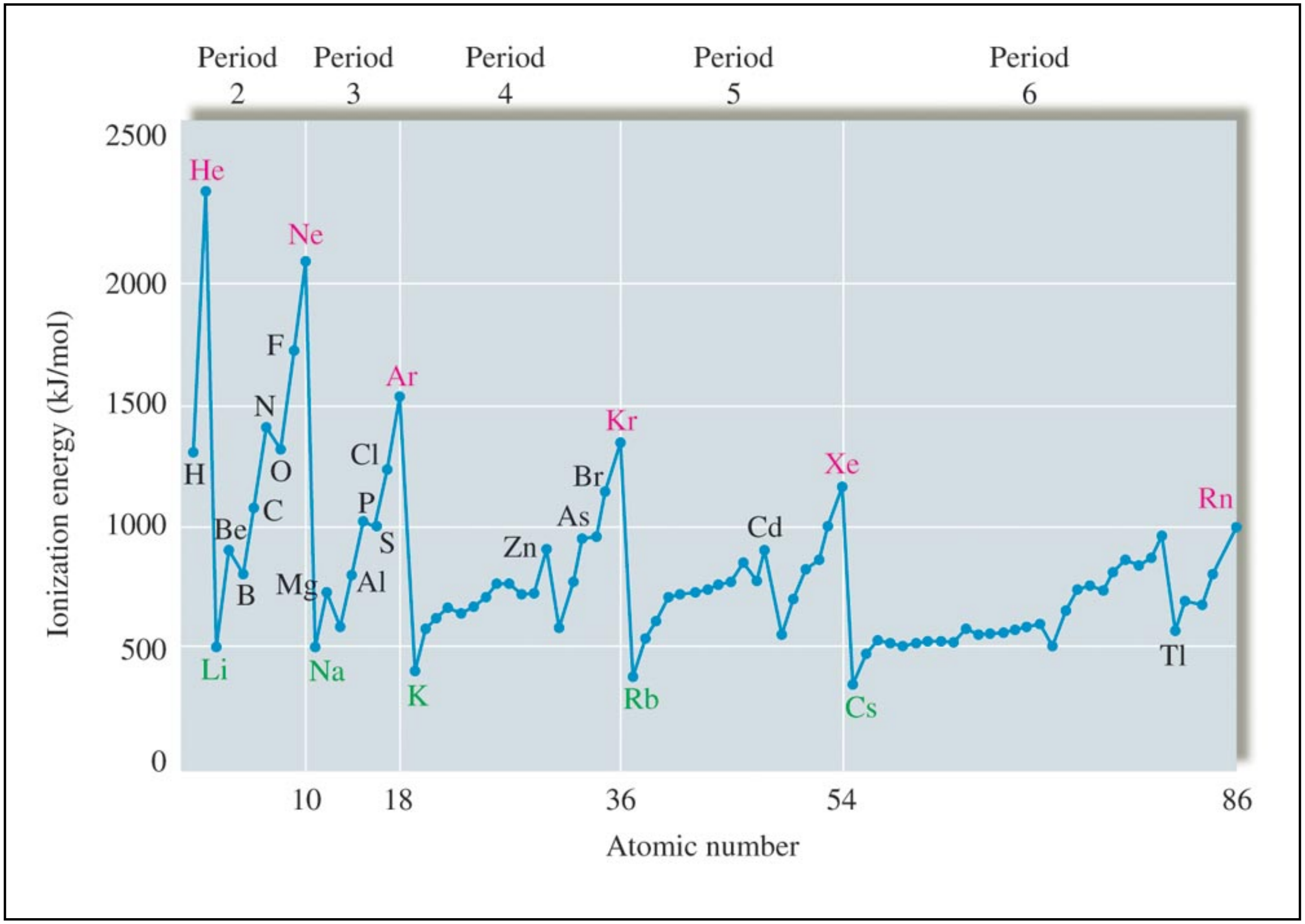
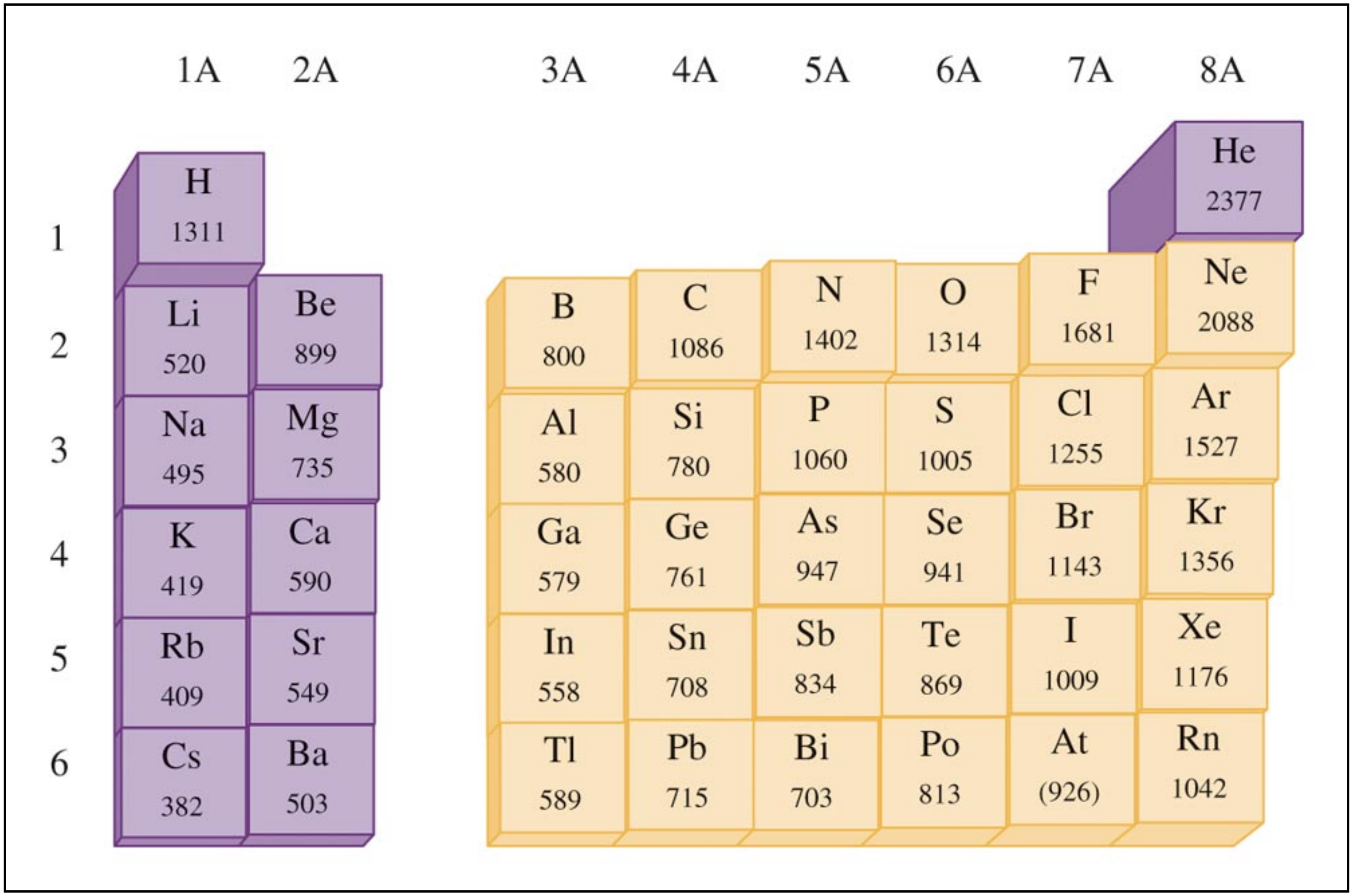


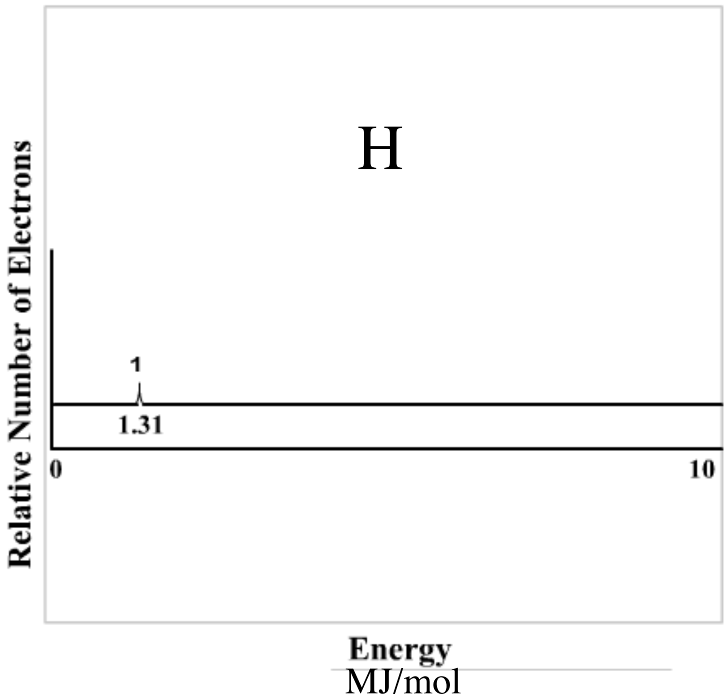
Figure 7.31 Trends in Ionization Energies (kj/mol) for the Representative Elements

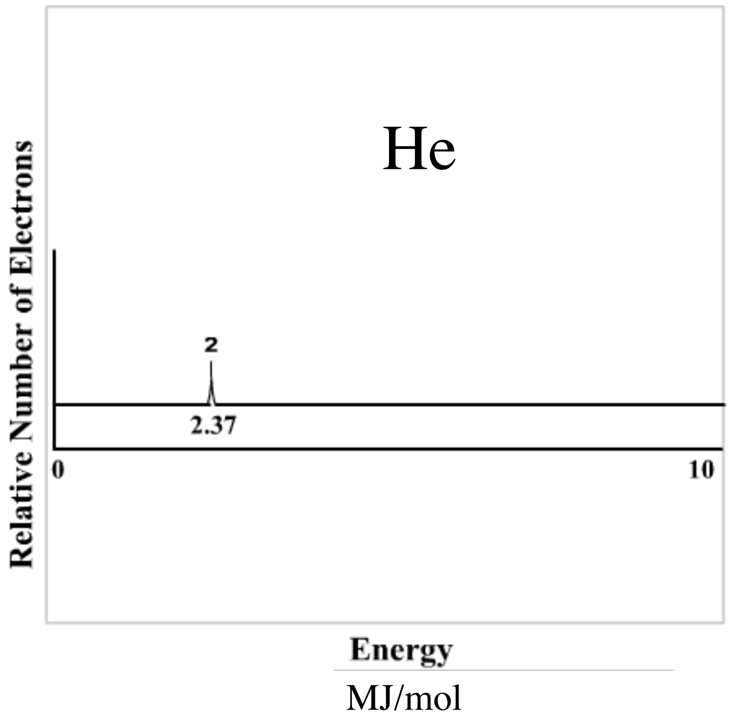


Photoelectron Spectroscopy (PES)

Determining ionization energy by bombarding atoms with light and ejecting electrons. Energy put in and given off are measured and the difference is the IE

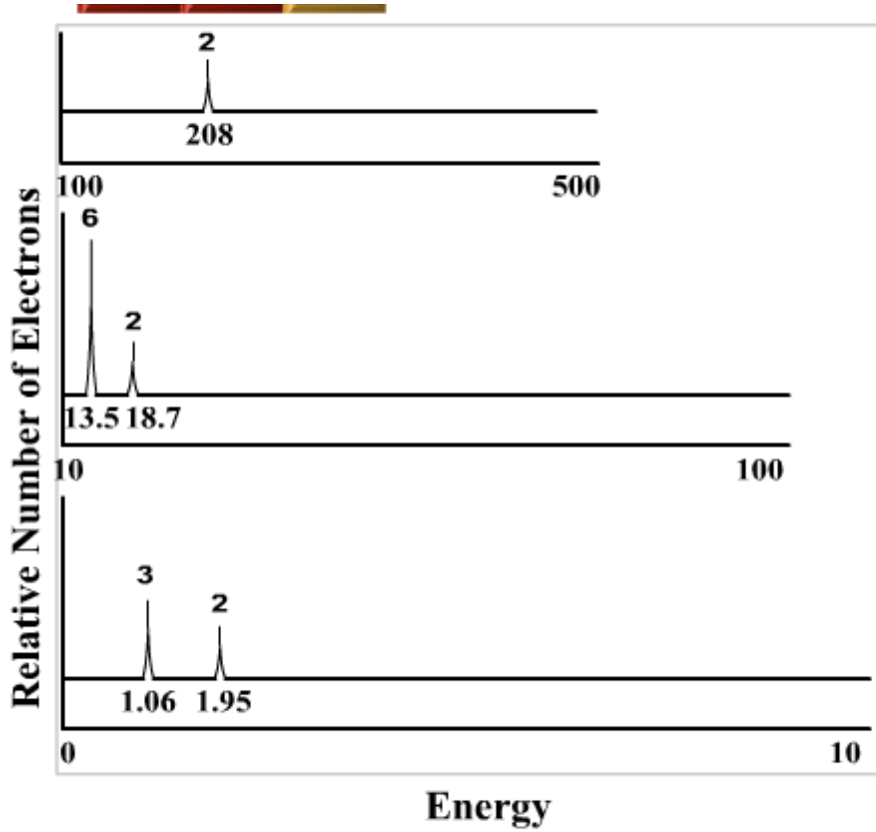
$$IE = E_{photon} - E_{emitted\ e}$$



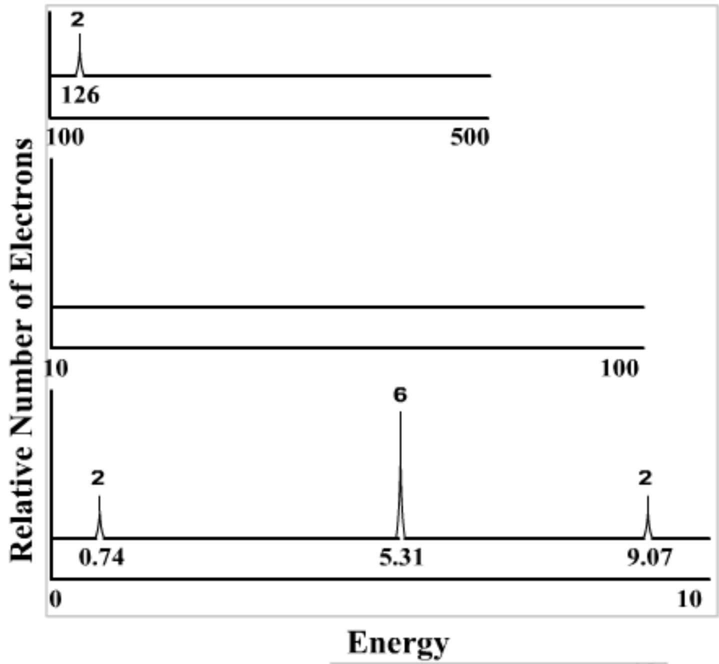


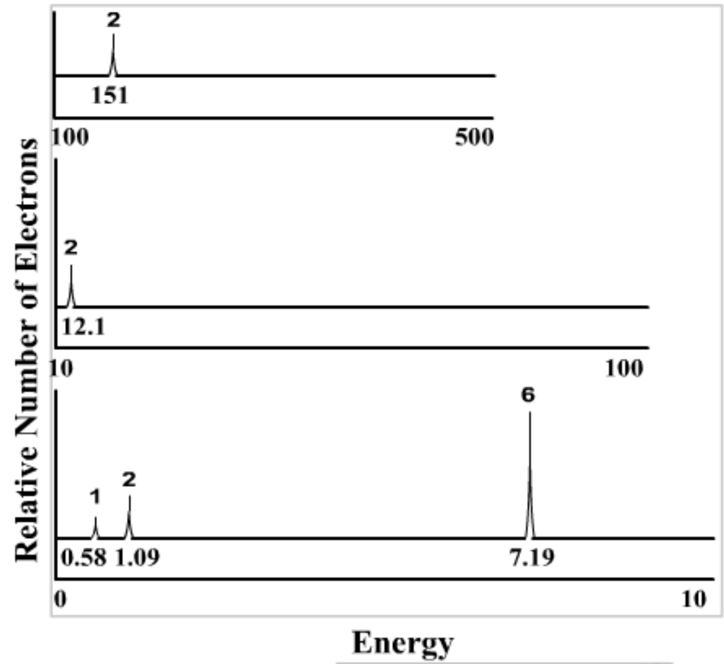
http://www.chem.arizona.edu/chemt/Flash/photoelectron.html

Determine the element From the following PES spectra.



Phosphorous





How many core e^- in each?	10	10
How many valence electrons in each?	10	10
Identify each element.	Mg	Al
Paramagnetic or Diamagnetic?	Diamagnetic	Paramagnetic

Compare the nuclear charges of the two elements

Why does the E to remove the last electron decrease?

Figure 7.32 The Electron Affinity Values for Atoms Among the First 20 Elements that Form Stable, Isolated X- Ions

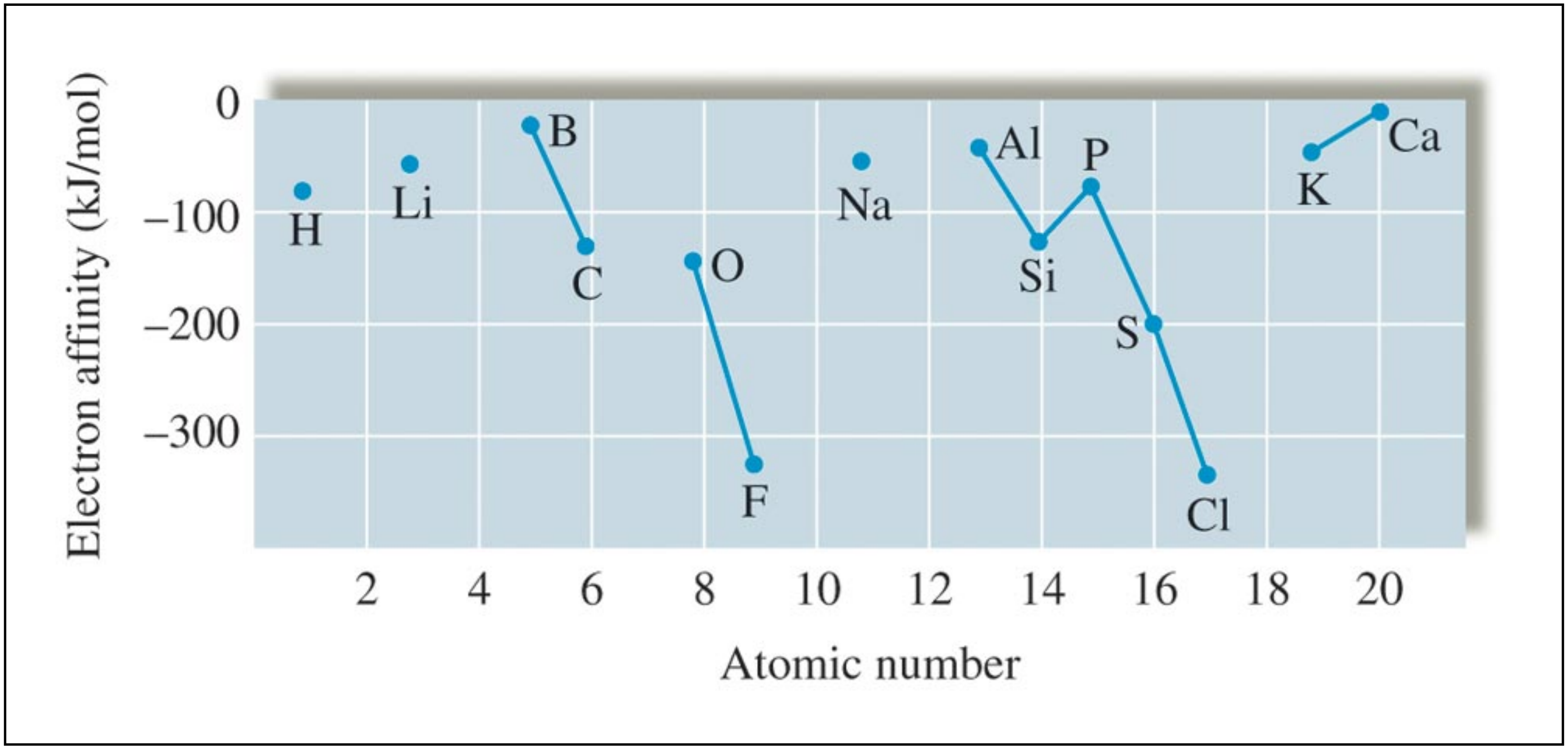


Table 7.7 Electron Affinities of the Halogens

TABLE 7.7 Electron Affinities of the Halogens

Atom	Electron Affinity (kJ/mol)
F	−327.8
Cl	−348.7
Br	−324.5
I	−295.2

Figure 7.33 The Radius of an Atom (r) is Defined as Half the Distance Between the Nuclei in a Molecule Consisting of Identical Atoms

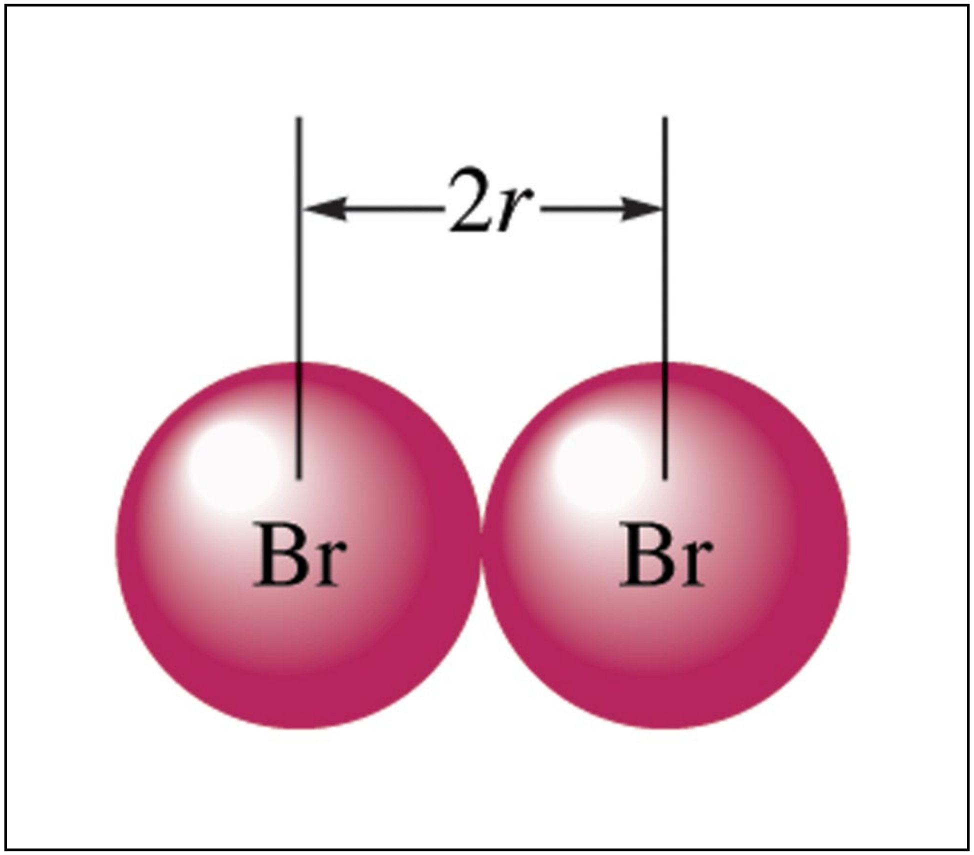
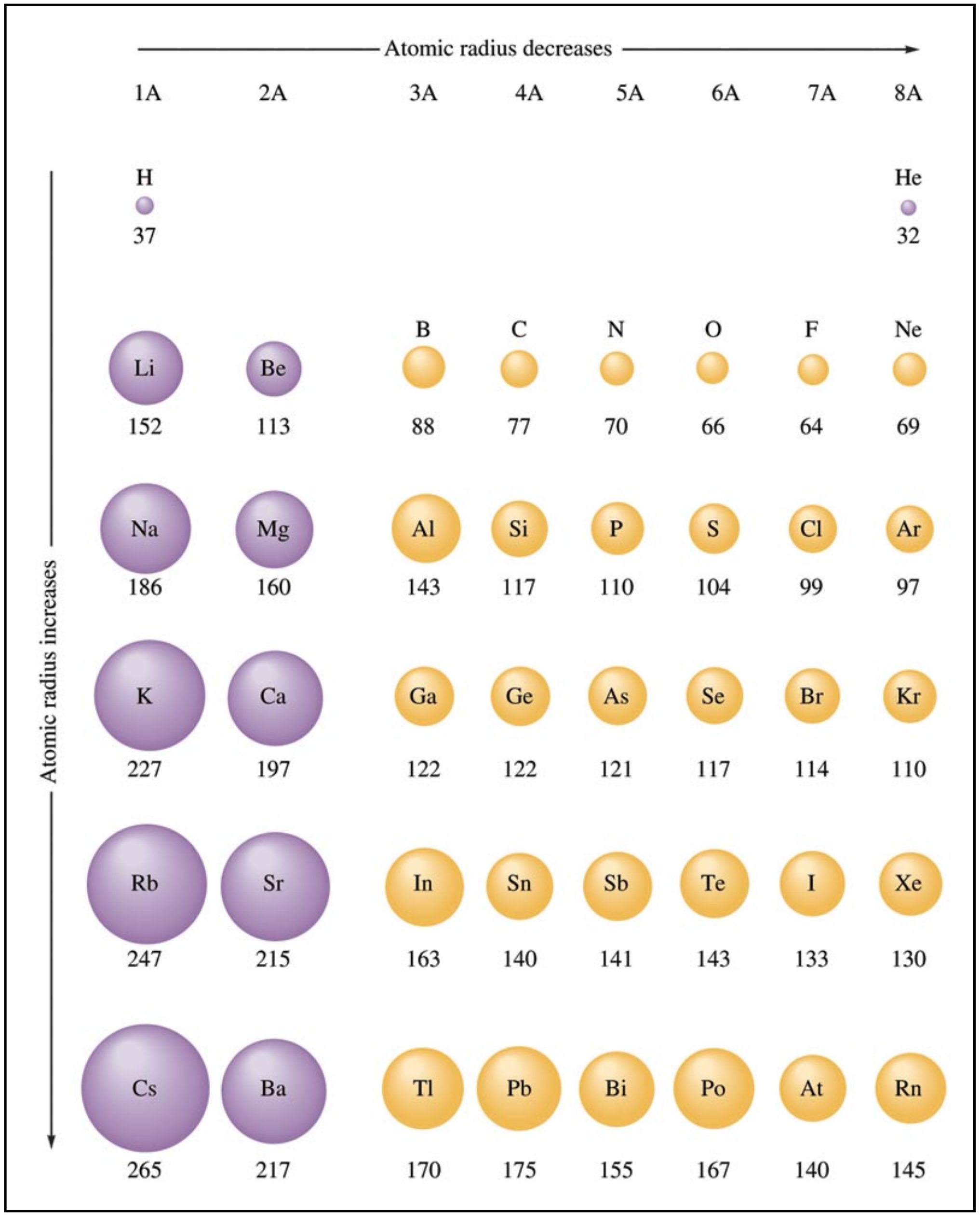
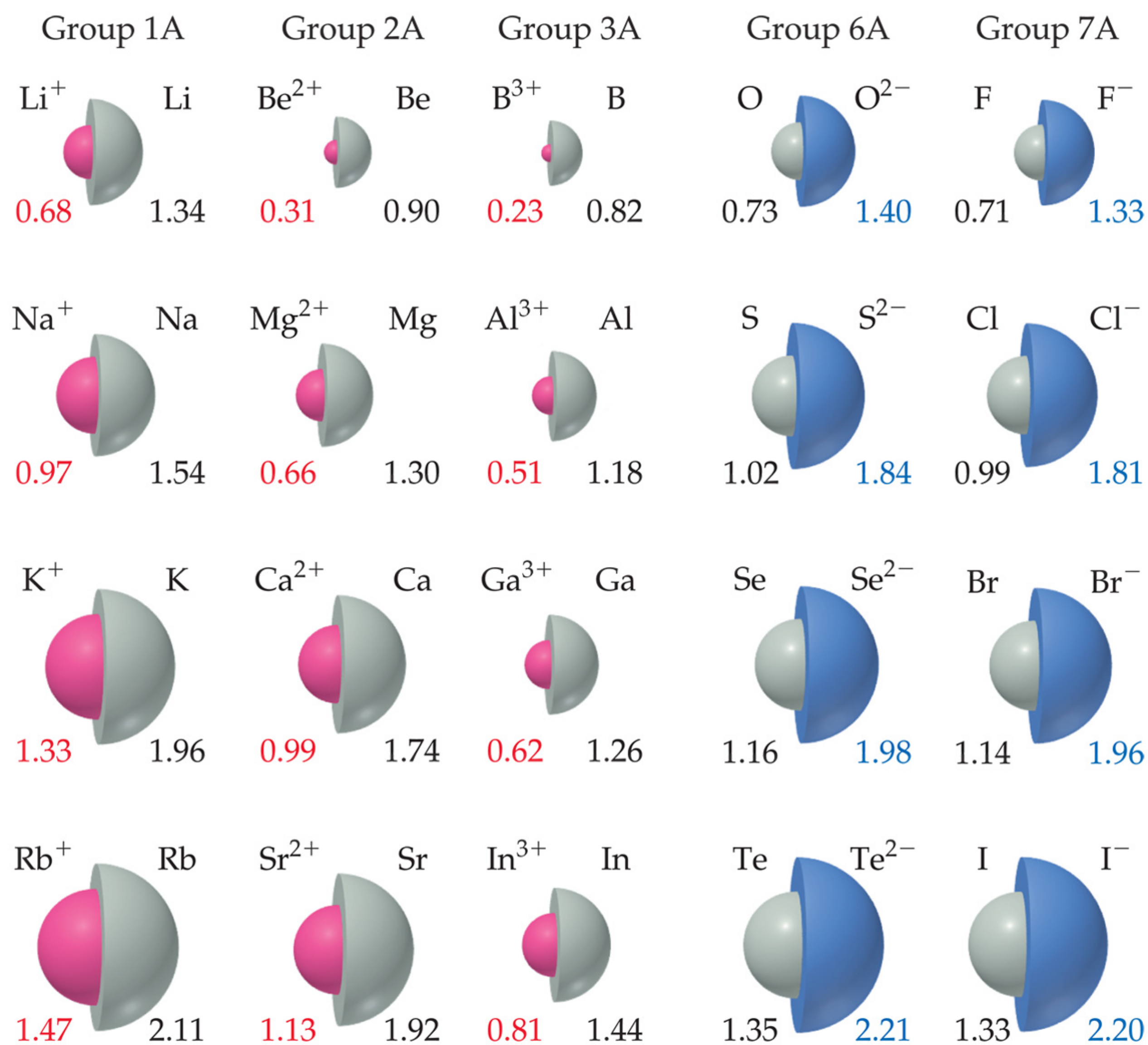


Figure 7.34 Atomic Radii (in Picometers) for Selected Atoms





Group 1A
Group 2A
Group 3A
Group 6A
Group 7A
Li+
Li
0.68
1.34
Be2+
Be
0.31
0.90
B3+
B
0.23
0.82
O
O2−
0.73
1.40
F
F−
0.71
1.33
Na+
Na
0.97
1.54
Mg2+
Mg
0.66
1.30
Al3+
Al
0.51
1.18
S
S2−
1.02
1.84
Cl
Cl−
0.99
1.81
K+
K
1.33
1.96
Ca2+
Ca
0.99
1.74
Ga3+
Ga
0.62
1.26
Se
Se2−
1.16
1.98
Br
Br−
1.14
1.96
Rb+
Rb
1.47
2.11
Sr2+
Sr
1.13
1.92
In3+
In
0.81
1.44
Te
Te2−
1.35
2.21
I
I−
1.33
2.20

Figure 7.35 Special Names for Groups in the Periodic Table

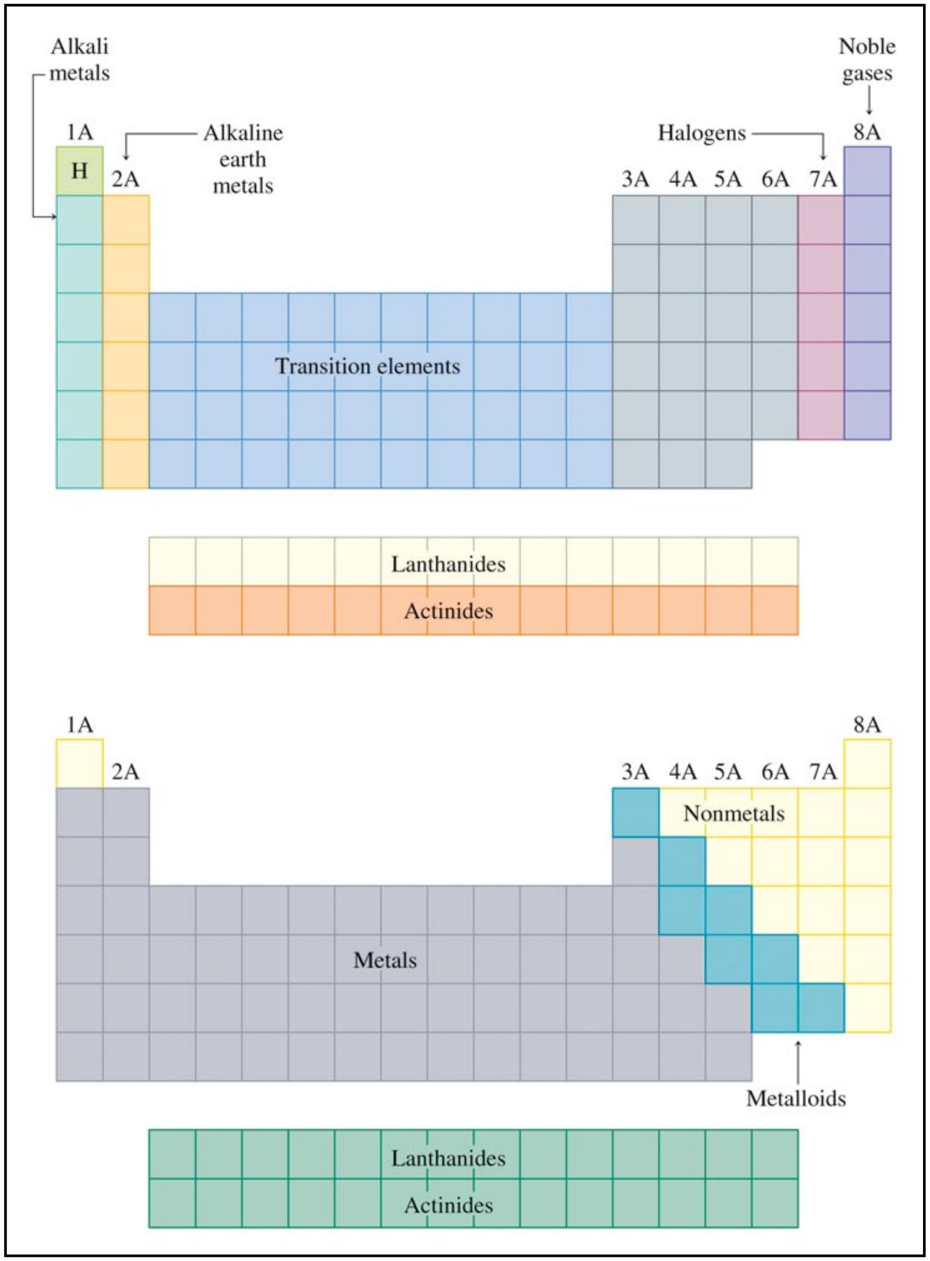


Table 7.8 Properties of Five Alkali Metals

TABLE 7.8 Properties of Five Alkali Metals

Element	Valence Electron Configuration	Density at 25°C (g/cm^3)	mp (°C)	bp (°C)	First Ionization Energy (kJ/mol)	Atomic (covalent) Radius (pm)	Ionic (M^+) Radius (pm)
Li	$2s^1$	0.53	180	1330	520	152	60
Na	$3s^1$	0.97	98	892	495	186	95
K	$4s^1$	0.86	64	760	419	227	133
Rb	$5s^1$	1.53	39	668	409	247	148
Cs	$6s^1$	1.87	29	690	382	265	169

Table 7.9 Hydration Energies for Li^+, Na^+, and K^+ Ions

TABLE 7.9 Hydration Energies for Li^+, Na^+, and K^+ Ions

Ion	Hydration Energy (kJ/mol)
Li^+	−510
Na^+	−402
K^+	−314